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ABSTRACT

A job analysis was conducted to define a knowledge domain necessary for newly licensed (certified) general science teachers to perform their jobs competently. The results of the job analysis will be used to develop test specifications for the Praxis II Subject Assessment in General Science. An initial draft domain of important knowledge statements was constructed by Educational Testing Service Test Development staff. The draft domain of 7 major knowledge areas and 278 specific knowledge statements was revised after review by an advisory committee of 3 teachers (one middle school, and two secondary school), 3 teacher educators, and a state administrator. The revised domain of 270 statements was sent, in survey form, to teachers and teacher educators. Responses of 178 teachers and teacher educators, a response rate of 26%, verified 153 statements as important and supported the major knowledge areas. These statements should be used to construct test specifications for a test of general science knowledge. Eight appendixes include the survey instrument and supplemental information about responses and methodology. Five tables summarize study findings. (Contains nine references.) (SLD)

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ED 385 585

THE PRAXIS SERIES
Professional Assessments for Beginning Teachers

A Job Analysis of the Knowledge Important for Newly Licensed (Certified) General Science Teachers

Richard J. Tannenbaum

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A Job Analysis of the Knowledge Important for Newly Licensed (Certified) General Science Teachers

by

Richard J. Tannenbaum

Division of Applied Measurement Research

Educational Testing Service

Princeton, New Jersey

November 1992

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A Job Analysis of the Knowledge Important
For Newly Licensed (Certified) General Science Teachers

Richard J. Tannenbaum

Executive Summary

A job analysis was conducted to define a knowledge domain important for newly licensed (certified) general science teachers to perform their jobs in a competent manner. The results of the job analysis will be used to develop test specifications for the Praxis II Subject Assessment in General Science.

An initial draft domain of important knowledge statements was constructed by Educational Testing Service (ETS) Test Development staff with subject-matter expertise in chemistry, physics, biology, and earth and space science (specific disciplines of science that are believed to constitute general science) and ETS Research staff with expertise in job analysis. In the process of developing the draft, the ETS subject-matter experts reviewed state licensure (certification) requirements and relevant professional literature.

The draft domain for general science consisted of seven major knowledge areas partitioned into various subareas and 278 specific knowledge statements. The seven major knowledge areas were: (1) **Scientific Methodology/Techniques/History**, (2) **Basic Principles of Science**, (3) **Physics**, (4) **Chemistry**, (5) **Biology**, (6) **Earth and Space Science**, and (7) **Science, Technology, and Society**.

The draft domain was them reviewed by an Advisory/Test Development Committee. This committee consisted of three teachers (one middle school and two secondary school), three teacher educators, and a state administrator with expertise in chemistry, physics, biology, and earth and space science. The purpose of this committee was to modify the draft domain so that it accurately reflected what the members of the committee believed were the knowledge important for newly licensed (certified) general science teachers. This modification process occurred during a two-day meeting held at ETS. The outcome of the modification included only minor wording changes and the addition and deletion of some knowledge statements.

The revised domain was then subject to verification/refutation through a national survey of general science education professionals (i.e., teachers, teacher educators, and state administrators). The participants were asked to rate the specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) general science teachers.

Three types of data analysis were conducted to support the development of content valid (content relevant) test specifications for the Subject Assessment in General Science: (1) means of the importance ratings were computed for each knowledge statement by groups of education professionals and by appropriate subgroups of respondents; (2) correlations of the profiles of

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these mean importance ratings were computed across the groups of education professionals and within the appropriate subgroups of respondents; and (3) percents were computed across each of the five response categories associated with the level of understanding rating scale for each knowledge statement. These percents were computed at the aggregate level of the survey respondents to provide more easily interpretable, and therefore, useful information to the Advisory/Test Development Committee. To be included in the mean and correlational analyses, a respondent category was required to have at least 30 respondents (e.g., ≥ 30 state administrators, ≥ 30 females). This is a necessary condition to ensure that the computed mean values are accurate estimates of the corresponding population mean values (Walpole, 1974).

A mean importance rating cutpoint of 2.50 (midpoint between moderately important and important) was established to designate knowledge statements as eligible (≥ 2.50) or ineligible (< 2.50) for inclusion in the development of test specifications.

The results of the mean analysis conducted by teachers and teacher educators (an insufficient number of respondents (n = 1) had identified themselves as state administrators for analysis) indicated 89 knowledge statements were rated less than 2.50. This represents 33% of the content domain. Twenty-eight additional knowledge statements were rated below 2.50 by one or more of the subgroups (geographic region, sex, teaching experience) of respondents. **In total, 117 of the 270 statements (43%) did not meet the 2.50 criterion for inclusion. Still, however, 57% of the domain (153 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements revealed a high level of agreement. The coefficients for comparisons among teachers and teacher educators was .81; and the coefficients generated by the subgroup analyses all exceeded .90.

The 153 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of general science teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Test Development Committee in their decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

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The results of the analysis of the level of understanding rating scale indicated that 66% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 31% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of the judged importance of the seven major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the general science knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined knowledge domain. With respect to importance (see Table 1), both teachers and teacher educators judged the content areas to be important (scale value of 3.00). With respect to content coverage (see Table 4), both teachers and teacher educators judged the content areas to be well covered (scale value of 4.00).

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A Job Analysis of the Knowledge Important
for Newly Licensed (Certified) General Science Teachers

Introduction

The Subject Assessments in the Sciences of The Praxis Series: Professional Assessments for Beginning Teachers™ offer a multiple-choice core test and one or more candidate-constructed-response modules. The optional modules include Content Area Performance Assessments that allow candidates to demonstrate in-depth understanding of the subject and Content-Specific Pedagogy modules to demonstrate knowledge about teaching the subject. The Praxis Series can be used by state agencies as one of several criteria for initial teacher licensure (certification). One of the Subject Assessments in the Sciences covers the subject area of general science. To identify the content domain of this examination and to support the content validity (content relevance) of this examination, a job analysis was conducted of the knowledge important for newly licensed (certified) general science teachers. This report will describe the job analysis. In particular, it will present the (1) methods used to identify and define the job-related knowledge, (2) types of statistical analysis conducted, (3) results of these analyses, and (4) implications of the results for developing test specifications.

Standards for Educational and Psychological Testing

The *Standards for Educational and Psychological Testing* (1985) is a comprehensive technical guide that provides criteria for the evaluation of tests, testing practices, and the effects of test use. It was developed jointly by the American Psychological Association (APA), the American Educational Research Association (AERA), and the National Council on Measurement in Education (NCME). The guidelines presented in the *Standards* have, by professional consensus, come to define the necessary components of quality testing. As a consequence, a testing program that adheres to the *Standards* is more likely to be judged to be valid (defensible) than one that does not.

There are two categories of criteria within the *Standards*, primary and secondary. Those classified as primary "should be met by all tests . . . unless a sound professional reason is available to show why it is not necessary, or technically feasible, to do so in a particular case. Test developers and users . . . are expected to be able to explain why any primary standards have not been met" (AERA/APA/NCME, 1985, p. 2). One of the primary standards is that the content domain of a licensure or certification test should be defined in terms of the importance of the content for competent performance in an occupation. "Job analyses provide the primary basis for defining the content domain." (p. 64).

The use of job analysis to define the content domain is a critical component in establishing the content validity of licensure and certification examinations. Content validity is the principle validation strategy used for these examinations. It refers to the extent to which the content covered by an examination overlaps with the important components (tasks, knowledge, skills, or abilities) of a job (Arvey & Faley, 1988). Demonstration of content validity is accomplished

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through the judgments of subject-matter experts. It is enhanced by the inclusion of large numbers of subject-matter experts who represent the diversity of the relevant areas of expertise (Ghiselli, Campbell, & Zedeck, 1981). The lack of a well-designed job analysis is frequently cited (by the courts) as a major cause of test invalidity.

Job Analysis

Job analysis refers to procedures designed to obtain descriptive information about the tasks performed on a job and/or the knowledge, skills, and abilities thought necessary to perform those tasks (Gael, 1983). The specific type of job information collected by a job analysis is determined by the purpose for which the information will be used. For purposes of developing licensure and certification examinations, a job analysis should identify the important knowledge or abilities necessary to protect the public -- interpreted as the importance of the content for competent performance in an occupation (*Standards for Educational and Psychological Testing*, AERA/APA/NCME, 1985). In addition, a well-designed job analysis should include the participation of various subject-matter experts (Mehrens, 1987); and the data collected should be representative of the diversity within the job. Diversity refers to regional or job context factors and to subject-matter-expert factors such as race\ethnicity, experience, and sex (Kuehn, Stallings, & Holland, 1990). The job analysis conducted for general science was designed to be consistent with the *Standards* and current professional practices.

Objectives of the Job Analysis Study

The objectives of this study were: (1) to construct a comprehensive domain of knowledge that is important for newly licensed (certified) general science teachers; and then (2) to obtain, using survey methodology, the independent judgments of a national sample of general science education professionals (teachers, teacher educators, state administrators) to verify or refute the importance of the domain of knowledge. The verification/refutation component serves a critical role to ensure that the domain (in whole or in part) is judged to be relevant to the job of a newly licensed (certified) general science teacher by a wide range of educational professionals. It is those knowledge areas that are verified to be important that will be used in the development of test specifications for The Praxis II Subject Assessment in General Science.

Method

In overview, the methodology consisted of defining the knowledge important for newly licensed (certified) general science teachers to perform their jobs in a competent manner. This was accomplished first by having subject-matter experts define a domain of knowledge important for newly licensed (certified) general science teachers and then by presenting these judgments for verification or refutation through a national survey of general science education professionals. This functions as a "check and balance" on the judgments of the subject-matter experts and reduces the likelihood that unimportant knowledge will be included in the development of the test specifications. The survey participants were general science teachers and state administrators whose names were obtained from the memberships of the (1) National Science Teachers Association and (2) National Science Supervisors Association. (It was not

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possible a priori to identify reliably teacher educators of general science.) The participants were asked to rate specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) general science teachers to perform their jobs in a competent manner. The specific steps in the job analyses are described below.

Build a Draft Domain of Knowledge

The first step in the process of conducting the job analysis was to construct a preliminary knowledge domain. This draft would function as the initial definition of the knowledge domain of newly licensed (certified) general science teachers. The domain was constructed by Educational Testing Service (ETS) Test Development staff with subject-matter expertise in chemistry, physics, biology, and earth and space science (specific disciplines of science that are believed to constitute general science) and ETS Research staff with expertise in job analysis. In the process of developing the draft, the ETS subject-matter experts reviewed state licensure (certification) requirements and relevant professional literature.

The draft domain for general science consisted of seven major knowledge areas partitioned into various subareas and 278 specific knowledge statements. The seven major knowledge areas were: (1) **Scientific Methodology/Techniques/History**, (2) **Basic Principles of Science**, (3) **Physics**, (4) **Chemistry**, (5) **Biology**, (6) **Earth and Space Science**, and (7) **Science, Technology, and Society**.

Advisory/Test Development Committee Meeting

Consistent with a content validity framework, the job analysis study was designed to obtain input from many subject-matter experts at several critical points in the domain definition process. To this end, an Advisory/Test Development Committee of three teachers (one middle school and two secondary school), three teacher educators, and a state administrator with expertise in chemistry, physics, biology, and earth and space science was formed (see Appendix A for list of members). This committee also had representation by race/ethnicity, sex, and geographic region. The purpose of this committee was to review the draft domain in terms of its overall structure, completeness, appropriateness of the knowledge statements, and clarity of wording. In addition, the members were asked to identify other content areas and/or knowledge statements that they believed should be added to the domain and to delete knowledge statements that they believed should not be included in the domain. In essence, the members were asked to modify the domain so that it accurately reflected what the committee believed were the knowledge statements important for newly licensed (certified) general science teachers. The committee also reviewed and approved the rating scales for the national survey and the biographical data that would be asked of the survey participants. The biographical data were collected to describe the composition of those who returned completed surveys and to permit analysis of the survey responses by various subgroups of respondents (e.g., males and females).

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The revision process occurred during a two-day meeting held at ETS. The meeting was led jointly by ETS Test Development and Research staff. (Prior to the meeting, the members of the committee were mailed a copy of the draft domain to review. They were informed about the purpose of the meeting and asked to come prepared to discuss their review of the draft domain.) During the course of the meeting, the domain was revised to reflect the consensus of the committee. This resulted in minor wording changes and the addition and deletion of some knowledge statements. However, no significant changes occurred in the structure of the domain.

Pilot Test of the Job Analysis Survey

Prior to the national administration, the job analysis survey was mailed to a small group of chemistry, physics, biology, and earth and space teachers. These pilot participants were asked to review the survey for clarity of wording and instruction, ease of use, and comprehensiveness of content coverage. They were asked to make their comments on a questionnaire that accompanied the survey and to mail the questionnaire and survey back to ETS in a postage-paid envelope. No significant revisions were suggested by the pilot participants.

Final Survey Format

The finalized job analysis survey (see Appendix B for a copy of the survey) consisted of three parts. Part I included the seven major content areas, 270 specific knowledge statements, and seven overall importance statements (one for each major content area). Space was also provided for respondents to add knowledge statements that they believed should be included in the domain. In addition, the respondents were asked to rate, using a 5-point scale, how well the knowledge statements within a major content area covered the important aspects of that major content area. This provides an indication of content coverage. The knowledge statements were judged using two rating scales. One was an importance scale:

> *How important is an understanding of this knowledge area for newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their jobs in a competent manner?*
>
> *(0) Of no importance*
> *(1) Of little importance*
> *(2) Moderately important*
> *(3) Important*
> *(4) Very important*

This scale is consistent with the *Standards* emphasis on identifying a content domain that is important for competent job performance. The other scale addressed the level of understanding needed for competent job performance:

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What level of understanding is typically needed by newly licensed (certified) general science teachers in each knowledge area?

(0) An understanding of the knowledge area is not needed
(1) Requires the ability to define the terms used in the knowledge area
(2) Requires the ability to comprehend the essential properties of the knowledge area
(3) Requires the ability to apply/utilize the knowledge area to address problems or questions
(4) Requires the ability to analyze the knowledge area into component parts and explain the interrelationships among the parts

This rating scale was designed to provide Test Development staff, responsible for developing test specifications, with information that may assist in their decisions about the level of cognitive complexity that should be represented on the specifications. Both of these rating scales were reviewed and approved by the Advisory/Test Development Committee.

Part II asked the participants to indicate the relative weight that each of the major content areas should receive on the examination. This was accomplished by their distributing 100 total points across the major content areas. These point distributions were easily converted into percentages, representing the percent of items that the survey respondents believed should be devoted to each area.

Part III was the background information section. The survey participants were asked to respond to several questions that described their demographic makeup (e.g., teaching experience, age, sex, race/ethnicity). This information was used to describe the survey respondents and to perform relevant subgroup analyses.

Administration of the Job Analysis Survey

The job analysis survey, accompanied by a letter of invitation to participate (see Appendix C for a copy of the letter), was mailed to 700 education professionals. The 700 education professionals represented: 650 teachers (13 per state) and 50 state administrators (1 per state). (It was not possible a priori to identify reliably teacher educators of general science.) These individuals were randomly selected from the memberships of the National Science Teachers Association and the National Science Supervisors Association. Approximately one week after the surveys were mailed, a follow-up postcard was mailed to the participants reminding them to complete and return the surveys.

The purpose of the survey administration was to identify a core of knowledge statements that relatively large numbers of education professionals judged to be relevant (verified to be important) to newly licensed (certified) general science teachers. This is accomplished by analyzing the mean importance ratings provided by the surveyed groups of educational professionals and by the appropriate subgroups of respondents. Knowledge statements that are judged to be important by **all** respondent groups and subgroups define the core. The core becomes the primary database for the development of test specifications. The derivation of test

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specifications from those knowledge statements verified to be important by the surveyed educational professionals provides a substantial evidential basis for the content validity (content relevance) of the Subject Assessment in General Science.

Results

Data Analyses of Survey Responses

Three types of data analysis were conducted to support the development of content valid (content relevant) test specifications for the Subject Assessment in General Science: (1) means of the importance ratings were computed for each knowledge statement by the groups of educational professionals and by the appropriate subgroups of respondents; (2) correlations of the profiles of these mean importance ratings were computed across the groups of educational professionals and within the appropriate subgroups of respondents; and (3) percents were computed across each of the five response categories associated with the level of understanding rating scale for each knowledge statement. These percents were computed at the aggregate level of the survey respondents to provide more easily interpretable, and therefore, useful information to the Advisory/Test Development Committee. To be included in the mean and correlational analyses, a respondent category was required to have at least 30 respondents (e.g., $\geq$ 30 state administrators, $\geq$ 30 females). This is a necessary condition to ensure that the computed mean values are accurate estimates of the corresponding population mean values (Walpole, 1974).

Means. The mean analysis is used to determine the level (absolute value) of importance attributed to the knowledge statements by each of the groups of surveyed education professionals and by appropriate subgroups of respondents (sex, race/ethnicity, geographic region, teaching experience). Knowledge statements that meet or exceed a mean importance value of 2.50 (to be discussed in a later section) by **all groups of education professionals** and by **all subgroups of respondents** may be included in the development of the test specifications. In addition, mean ratings were computed for the responses to the content coverage section and the recommendation for test content section of the job analysis survey.

Correlations. The correlational analysis is used to determine the extent of agreement among the groups of education professionals and within the subgroups of respondents about the relative importance of the knowledge statements. Relative importance refers to the similarity of the pattern of mean ratings generated by the different respondent groups. For example, the profile of 270 mean ratings for general science teachers is correlated with the profile of 270 mean ratings for state administrators. If these two profiles are similar (the shapes of the profiles are complementary), the value of the correlation coefficient will be close to 1.00.

Percents. The percent analysis may be used by test development committees to guide their decisions about the level of cognitive complexity that should be represented on the examinations. By inspecting where among the five response categories the largest percentages are located, test developers may, more accurately, be able to construct examination items at an appropriate cognitive level for beginning (newly licensed or certified) general science teachers.

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Criterion for Interpretation of Mean Importance Ratings

Since the purpose of job analysis is to ensure that only the more important knowledge statements are included in the development of test specifications, a criterion (cutpoint) for inclusion needs to be established. A reasonable criterion that has been used in a similar job analysis study (Rosenfeld & Tannenbaum, 1991) is a mean importance rating that represents the midpoint between moderately important and the next higher scale value. For the importance rating scale used in the present job analysis, the value of this criterion is 2.50 (midpoint between moderately important and important). It is believed that this criterion is consistent with the intent of content validity, which is to include important knowledge in the assessment measure and to exclude unimportant knowledge from the assessment measure. Therefore, knowledge statements that receive a mean importance rating of 2.50 or more may be considered eligible for inclusion in the development of test specifications; knowledge statements that receive a mean rating of less than 2.50 may not be considered for inclusion. (However, because survey participants were not involved in the development of the content domain, they may lack certain insights that the Advisory/Test Development Committee members have due to their high level of involvement in the definition of the domain. As a consequence, if the committee believes that a knowledge statement rated below 2.50 should be included in the specifications and the committee can provide *compelling written rationales*, that knowledge statement may be reinstated for inclusion in the test specifications.)

Survey Respondents

Response rate. Of the 700 total surveys that were mailed, nine were returned due to an invalid mailing address. Thus, 691 surveys were actually administered. Of these 691, 178 were returned. This represents an overall response rate of 26% (178/691).

Demographic characteristics of the aggregate of the survey respondents. Sixty-nine percent of the respondents were between the ages of 35 years and 54 years. Fifty-four percent were males and 46% were females. The majority of respondents (88%) were White. Half (50%) had 11 or more years of teaching experience in general science. Seventy percent identified themselves as regular teachers (not substitutes); less than 1 percent identified themselves as state administrators; and 20% identified themselves as college faculty. (Thus, although it was not possible a priori to identify college faculty in the sampling plan, a sufficient number of respondents (n=33) had identified themselves as such for subsequent analysis. In contrast, an insufficient number of respondents (n=1) had identified themselves as state administrators for subsequent analysis.) Twenty-six percent of the respondents were from the Northeast region of the country; 27% were from the Central region; 31% were from the Southern region; and 15% were from the Far West region. A complete breakdown of the demographic characteristics of the respondents is provided in Appendix D.

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Results of Data Analyses: Teachers and Teacher Educators

Mean importance. The mean importance rating for each of the 270 knowledge statements is provided in Appendix E. The means are presented for (1) teachers (n=119) and (2) teacher educators (n=33). Inspection of these distributions of mean ratings indicated that teachers rated 27% of the knowledge statements (n=74) 3.00 (important) or higher; teacher educators rated 29% of the knowledge statements (n=79) 3.00 or higher. A comparison of the means across the two groups indicated that teacher educators rated 144 knowledge statements (53%) higher than did teachers.

The overall mean importance ratings for the seven major content areas were also computed for teachers and teacher educators. The means are presented in Table 1. All the means were close to or exceeded 3.00. This indicates that each major content area was judged to be important by both groups of respondents.

Table 1
Overall Mean Importance Ratings for Each of the Seven Major Knowledge Areas by Teachers and Teacher Educators

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	3.37	3.36
Basic Principles of Science	3.15	3.13
Physics	2.95	3.18
Chemistry	2.94	3.07
Biology	3.47	3.38
Earth and Space Science	3.27	3.07
Science, Technology, and Society	3.21	3.10

As previously discussed, knowledge statements that received a mean importance rating of less than 2.50 (midpoint between moderately important and important) may not be considered for inclusion in the development of test specifications, unless a *compelling written rationale* is provided by the committee for their reinstatement. Those knowledge statements rated less than 2.50 by the teachers and/or the teacher educators are presented in Appendix F. Of the 270 individual knowledge statements, 89 (33%) were rated below 2.50; and of these 89 statements, approximately one-third (35%) were rated below 2.50 only by the teachers.

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Correlation of the profiles of mean importance ratings. The profiles of mean importance ratings for the teachers and teacher educators were correlated. The value of the correlation coefficient was .81. This indicates that there is a high level of agreement between the two respondent groups in terms of the relative importance of the knowledge statements.

Percents. The percent of responses for each of the five categories associated with the level of understanding rating scale was computed for the aggregate of the survey respondents. This analysis provides some overall guidance with respect to the level of cognitive complexity that should be represented on the Subject Assessment in General Science. The percents are displayed in Appendix G. Inspection of these percent distributions indicates that for 178 knowledge statements the two highest percentages were between levels 2 (*comprehension*) and 3 (*application/utilization*); and for 83 knowledge statements the two highest percentages were between levels 3 and 4 (*analysis*).

Results of Data Analyses: Subgroups of Respondents

Mean importance. A significant contribution towards the accumulation of evidence in support of the job-relevance of the Subject Assessment in General Science is the verification of the importance of the knowledge statements by a wide range of education professionals. Therefore, mean importance ratings for each knowledge statement were computed for the following subgroups of respondents: (1) geographic region (Northeast, n=46; Central, n=48; Southern, n=55); (2) sex (female, n=81; male, n=95); and (3) teaching experience[1] ($\leq$ 10 years, n=46; >10 years, n=69). The means are presented in Appendix H. An analysis of importance ratings by geographic region is consistent with recent legal emphasis on addressing regional job variability when conducting job analysis for content domain specification purposes (Kuehn et al., 1990). The three geographic regions included for analysis are consistent with the categorization established by the National Association of State Directors of Teacher Education and Certification (NASDTEC). (The fourth region recognized by NASDTEC, Far West, was not included because there was an insufficient number of respondents from that region, n=27.) Sex was included because it represents a protected "class" under Title VII of the Civil Rights ACT of 1964. (Race/ethnicity was not included in the subgroup analyses because of the insufficient number of minority respondents, n=20.) The dichotomous breakdown of teaching experience at the 10-year point was chosen so that the judgments of relatively less experienced teachers will be represented and so that the judgments of relatively more experienced teachers will be represented.

The results of the subgroup analysis indicated that 28 additional knowledge statements (i.e., beyond the 89 statements previously identified by the mean analysis conducted on the teachers and teacher educators) were judged to be below the 2.50 cutpoint. The 28 statements are presented in Table 2. Inspection of Table 2 indicates that respondents from the Northeast and Central regions and respondents with less than or equal to 10 years of teaching experience account solely for 27 of the 28 flagged statements.

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[1] Teaching experience includes only those respondents who had identified themselves as regular teachers or permanent substitutes.

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Table 2
Knowledge Statements Rated Below 2.50 by Geographic Region, Sex, and Teaching Experience

		GEOGRAPHIC REGION			SEX		TEACHING EXPERIENCE	
		NE	C	S	F	M	≤10	>10
		N=46	N=48	N=55	N=81	N=95	N=46	N=69
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY								
9	Significant figures in measurement and calculation						2.39	
B. BASIC PRINCIPLES OF SCIENCE								
33	Heat cap./thermal exchange/heat of fusion and vaporization	2.41	2.41			2.48	2.24	
36	First law of thermodynamics	2.44						
43	Chemical properties related to electron configuration		2.40				2.48	
C. PHYSICS								
51	Rel. among position, velocity, and centripetal acceleration for uniform circular motion						2.38	
74	Motors		2.47				2.48	
75	Sources of EMF (e.g., batteries, solar cells, generators)		2.49					
93	Laser light		2.47					
D. CHEMISTRY								
114	Rel. among phases of matter, forces between particles, particle energy	2.47						
116	Rel. among volume/pressure/temperature/quantity for ideal gases	2.38					2.42	
121	Equation balancing from written descriptions of chemical reactions	2.49						
122	General types of chemical reactions	2.44					2.49	
135	Selective nature of solvents (e.g., like dissolves like)	2.47	2.43				2.30	
136	Effects of temperature and pressure on solubility		2.49					
E. BIOLOGY								
160	Causes and results of mutations		2.41				2.40	
163	Non-Mendelian inheritance (e.g., multiple genes)	2.31					2.45	
166	Historical developments relating to the origin of life		2.40					
168	Theories and patterns of evolution						2.49	

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Table 2 (cont.)

		GEOGRAPHIC REGION			SEX		TEACHING EXPERIENCE	
		NE	C	S	F	M	≤10	>10
		N=46	N=48	N=55	N=81	N=95	N=46	N=69
F. EARTH AND SPACE SCIENCE								
204	General types of minerals (e.g., silicates, carbonates)		2.44					
225	Geologic time scale		2.44					
229	Mass extinctions	2.44	2.30				2.48	
230	Wind-generated waves (e.g., formation, motion)		2.16				2.41	
232	Ocean currents (global and local; surface and deep)		2.35					
235	Physical and chemical properties of the ocean		2.42				2.49	
238	Nutrient cycles of the ocean		2.37					
243	Global wind belts		2.47					
257	Large units of distance (e.g., light-year,)		2.36					
258	Origin and life cycle of stars		2.32					

Correlations of the profiles of mean importance ratings. Correlation coefficients were computed for the profiles of mean importance ratings for the same subgroups used in the mean analysis. The coefficients are presented in Table 3. All the values exceeded .90. This indicates that there is a very high level of agreement within the subgroups of respondents in terms of the relative importance of the knowledge statements.

Mean Ratings of Content Coverage

The survey participants were asked to rate, using a 5-point scale, how well the knowledge statements within a major content area covered the important aspects of that major content area. Responses to this provide an indication of the adequacy (comprehensiveness) of the domain of knowledge. The scale values ranged from a low of 1 (very poorly) to a high of 5 (very well); the midpoint of the scale was value 3 (adequately). The means of these ratings for teachers and teacher educators are presented in Table 4. All the means were close to or exceeded 4.00. This indicates that both groups of respondents judged the content areas to be well covered.

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Table 3
Correlations of the Profiles of Mean Importance Ratings by Geographic Region, Sex, and Teaching Experience

	1	2	3
GEOGRAPHIC REGION			
1. Northeast		.93	.93
2. Central			.94
3. Southern			
SEX			
1. Female		.95	
2. Male			
TEACHING EXPERIENCE (years)			
1. ≤ 10		.96	
2. > 10			

Table 4
Mean Ratings of Content Coverage

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	4.04	4.09
Basic Principles of Science	3.94	3.88
Physics	4.06	4.03
Chemistry	4.14	4.00
Biology	4.19	4.44
Earth and Space Science	4.13	3.87
Science, Technology, and Society	4.03	3.79

Mean Percentage Weights for Test Content Emphasis

The survey participants were asked to indicate the weight that each of the seven major content areas should receive on the examination. This information may be used by test development committees to assist in their decisions about how much emphasis the content areas should receive on the test specifications. To obtain the weights, the participants were asked to distribute a total of 100 points across the major areas. The mean values were then converted into percentages. The mean percentage weights for teachers and teacher educators are presented in

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Table 5. The teachers distributed the points in such a way as to approximate equal weighting across the content areas (**Biology** and **Basic Principles of Science** received slightly more emphasis than the other content areas). The teacher educators emphasized **Physics**, **Chemistry**, **Biology**, and **Basic Principles of Science** more than the other content areas.

Table 5
Mean Percentage Weights

	Means	
Major Content Areas	Teachers	Teacher Educators
Scientific Methodology/Techniques/History	13.18	12.06
Basic Principles of Science	15.94	15.55
Physics	13.21	16.61
Chemistry	13.36	16.16
Biology	15.97	15.68
Earth and Space Science	14.68	12.68
Science, Technology, and Society	13.75	11.19

Summary and Conclusion

A job analysis was conducted to define a knowledge domain important for newly licensed (certified) general science teachers to perform their jobs in a competent manner. The results of the job analysis will be used to develop test specifications for the Subject Assessment in General Science.

An initial draft domain of important knowledge statements was constructed by ETS Test Development staff with expertise in chemistry, physics, biology, and earth and space science and ETS Research staff with expertise in job analysis. This draft domain was then reviewed, modified, and approved by an external Advisory/Test Development Committee. The revised knowledge domain was then subjected to verification/refutation through the use of a national survey of general science education professionals. The survey participants were asked to rate specific knowledge statements in terms of *importance* for and *level of understanding* needed by newly licensed (certified) general science teachers. A mean importance cutpoint of 2.50 (midpoint between moderately important and important) was established to designate knowledge statements as eligible (≥ 2.50) or ineligible (< 2.50) for inclusion in the development of test specifications.

The results of the mean analysis conducted by teachers and teacher educators indicated 89 knowledge statements were rated less than 2.50 (see Appendix F). This represents 33% of the content domain. Twenty-eight additional knowledge statements were rated below 2.50 by one or

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more of the subgroups of respondents (see Table 2). **In total, 117 of the 270 statements (43%) did not meet the 2.50 criterion for inclusion. Still, however, 57% of the domain (153 statements) is eligible for inclusion in the development of test specifications.**

The computation of correlation coefficients to assess agreement in terms of perceived relative importance of the knowledge statements revealed a high level of agreement. The coefficients for comparisons among teachers and teacher educators was .81; and the coefficients generated by the subgroup analyses all exceeded .90.

The 153 knowledge statements that were verified to be important by the surveyed teachers, teacher educators, and the subgroups should be used as the foundation for the development of test specifications. Test specifications that are linked to the results of a job analysis provide support for the content validity of the derived assessment measures and may be considered as part of an initial step in ensuring the fairness (to subgroups of general science teacher candidates) of the derived assessment measures. It is reasonable to assume that, due to testing and psychometric constraints (e.g., time limits, ability to measure reliably some content), not all of the verified content may be included on the assessment measures. One source of information that may be used to guide the Test Development Committee in their decision of what verified content to include on the assessment measures is the mean importance rating. Although a rank ordering of the content by mean importance rating is not implied, it is recommended that initial consideration be given to content that is well above the cutpoint and represents the appropriate breadth of content coverage.

The results of the analysis of the level of understanding rating scale indicated that 66% of the knowledge statements should be measured between the levels of *comprehension* and *application/utilization*; and an additional 31% should be measured between the levels of *application/utilization* and *analysis*.

Evidence was also provided in this study of the judged importance of the seven major content areas and the comprehensiveness of the knowledge domain. These two pieces of information have implications for the adequacy of the general science knowledge domain. If the domain was adequately defined then each major content area should have been judged to be important and well covered. The results support the adequacy of the defined knowledge domain. With respect to importance (see Table 1), both teachers and teacher educators judged the content areas to be important (scale value of 3.00). With respect to content coverage (see Table 4), both teachers and teacher educators judged the content areas to be well covered (scale value of 4.00).

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Appendix A

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Appendix B

Job Analysis Survey

JOB ANALYSIS INVENTORY FOR TEACHERS OF GENERAL SCIENCE

By

Educational Testing Service
Princeton, New Jersey

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B2

INTRODUCTION

Educational Testing Service (ETS) is developing a new generation of assessments for the purpose of licensing (certifying) teachers. The inventory that follows is part of our development effort and is designed to gather information concerning the job of a **newly licensed teacher of general science courses** (also including physical science courses, life science courses, and earth science courses primarily grades 7-9). It was developed by high school teachers, college faculty, and state department of education officials, along with ETS staff.

Those who constructed this inventory recognize that teachers of general science courses are required to teach students with varying backgrounds and levels of ability. For this reason, the collaborators believe that teachers should have a broad and deep understanding of general science in order to teach it. The inventory asks you to respond to a list of statements and to judge (a) the importance of the knowledge statements for newly licensed (certified) teachers of general science courses and (b) the level of understanding needed by newly licensed (certified) teachers of general science courses. **Please do not relate each statement to your own job but rather to what you believe a newly licensed teacher of general science should know.**

The information you provide will guide the development of the NTE General Science module. In addition to the development of a General Science module, this study will also contribute to our understanding of general science teaching as a profession. We expect the results of the study to be widely disseminated and to be very useful to the profession.

The inventory has been mailed to a group of approximately 800 professionals. Its value is directly related to the number of individuals who return their completed inventories. Because you represent a large number of professionals, your responses are extremely important. The inventory requires approximately 60 minutes to complete. Please return your completed inventory within 10 days.

PART I - KNOWLEDGE AREAS FOR GENERAL SCIENCE TEACHERS

The purpose of this inventory is to determine what you believe newly licensed (certified) teachers of general science courses should know in order to perform their job in a competent manner. On the following pages you will find seven major content areas and, beneath each, a list of knowledge and ability statements that define the particular content area. The order of presentation of the seven content areas in the inventory is not meaningful.

The seven content areas are:

A. **SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY**
B. **BASIC PRINCIPLES OF SCIENCE**
C. **PHYSICS**
D. **CHEMISTRY**
E. **BIOLOGY**
F. **EARTH AND SPACE SCIENCE**
G. **SCIENCE, TECHNOLOGY, AND SOCIETY**

For each statement within each of these content areas, you will be asked to make the following judgments:

How important is an understanding of this knowledge area for newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their jobs in a competent manner?

(0) Of no importance
(1) Of little importance
(2) Moderately important
(3) Important
(4) Very important

What level of understanding is typically needed by newly licensed (certified) general science teachers in each knowledge area?

(Note: These levels are hierarchically arranged: level #2 subsumes level #1; level #3 subsumes levels #2 and #1; level #4 subsumes levels #3, #2, and #1. The zero (0) point is not subsumed by any other scale point.)

(0) An understanding of the knowledge area is not needed.
(1) Requires the ability to define the terms used in the knowledge area.
(2) Requires the ability to comprehend the essential properties of the knowledge area.
(3) Requires the ability to apply/utilize the knowledge area to address problems or questions.
(4) Requires the ability to analyze the knowledge area into component parts and explain the interrelationships among the parts.

Circle your responses using the scales adjacent to each statement. To familiarize yourself with the content areas and statements, you may wish to glance through Part I before making your judgments.

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A.	SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY	IMPORTANCE	LEVEL OF UNDERSTANDING
	Methodology and Philosophy		
1.	Scientific methods (e.g., formulation of problem, hypotheses, experiments, evaluation of data, feedback, conclusions)	0 1 2 3 4	0 1 2 3 4
2.	Facts, models, theories, and laws	0 1 2 3 4	0 1 2 3 4
3.	Design of experiments (e.g., controls, independent and dependent variables)	0 1 2 3 4	0 1 2 3 4
4.	Observations, interpretations, and inferences	0 1 2 3 4	0 1 2 3 4
5.	Qualitative and quantitative observations	0 1 2 3 4	0 1 2 3 4
6.	History of science, including contributions of various cultures	0 1 2 3 4	0 1 2 3 4
	Mathematics, Measurements, and Data Manipulation		
7.	The metric system	0 1 2 3 4	0 1 2 3 4
8.	Scientific notation	0 1 2 3 4	0 1 2 3 4
9.	Significant figures in measurement and calculation	0 1 2 3 4	0 1 2 3 4
10.	Unit/dimensional analysis	0 1 2 3 4	0 1 2 3 4
11.	Experimental errors (e.g., sources, quantifications, precision, accuracy)	0 1 2 3 4	0 1 2 3 4
12.	Measures of central tendency and dispersion (e.g., mean, median, mode, standard deviation, range)	0 1 2 3 4	0 1 2 3 4
13.	Mathematical relationships and patterns in numerical data (e.g., direct, inverse, trigonometric, exponential, period)	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
14. Simple digital (binary) logic	0 1 2 3 4	0 1 2 3 4
15. Presentation and interpretation of data in tables, graphs, charts, and maps	0 1 2 3 4	0 1 2 3 4
Laboratory, Field Activities, and Safety		
16. Laboratory and field equipment (e.g., balances, scales, ammeters, voltmeters, glassware, thermometers, barometers, burners, microscopes, compasses, stopwatches)	0 1 2 3 4	0 1 2 3 4
17. Preparation of specimens and materials (e.g., biological specimens, solutions, mixtures)	0 1 2 3 4	0 1 2 3 4
18. Safety procedures	0 1 2 3 4	0 1 2 3 4
19. Laboratory and field hazards	0 1 2 3 4	0 1 2 3 4
20. Storage and disposal of materials	0 1 2 3 4	0 1 2 3 4
21. **Overall evaluation of the importance of Scientific Methodology/Techniques/History**	0 1 2 3 4	

22. How well do the knowledge areas in section A cover the important aspects of Scientific Methodology/Techniques/History?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC PRINCIPLES OF SCIENCE		IMPORTANCE	LEVEL OF UNDERSTANDING
23.	Physical and chemical properties (e.g., states of matter, homogeneous, heterogeneous)	0 1 2 3 4	0 1 2 3 4
24.	Particulate nature of matter (e.g., atoms, ions, molecules)	0 1 2 3 4	0 1 2 3 4
25.	Elements, names, symbols, occurrence, and relative abundance	0 1 2 3 4	0 1 2 3 4
26.	Physical and chemical changes	0 1 2 3 4	0 1 2 3 4
27.	Conservation of mass/energy	0 1 2 3 4	0 1 2 3 4
28.	Forms of energy (e.g., kinetic, potential, mechanical, sound, magnetic, electrical, light, heat, chemical)	0 1 2 3 4	0 1 2 3 4
29.	Energy transformations	0 1 2 3 4	0 1 2 3 4
	Heat and Thermodynamics		
30.	Heat versus temperature	0 1 2 3 4	0 1 2 3 4
31.	Temperature scales and measurements	0 1 2 3 4	0 1 2 3 4
32.	Conduction, convection, and radiation	0 1 2 3 4	0 1 2 3 4
33.	Heat capacity, heat of fusion, and heat of vaporization	0 1 2 3 4	0 1 2 3 4
34.	Phase changes of water from ice to steam	0 1 2 3 4	0 1 2 3 4
35.	Expansion and contraction	0 1 2 3 4	0 1 2 3 4
36.	First law of thermodynamics	0 1 2 3 4	0 1 2 3 4
37.	Second law of thermodynamics	0 1 2 3 4	0 1 2 3 4
	Atomic and Nuclear Structure		
38.	Historical development of atomic models	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

B. BASIC PRINCIPLES OF SCIENCE (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
39.	Structure of the atom (e.g., electrons, protons, neutrons)	0 1 2 3 4	0 1 2 3 4
40.	Atomic mass, atomic number, mass number, and isotopes	0 1 2 3 4	0 1 2 3 4
41.	Nuclear forces and binding energy	0 1 2 3 4	0 1 2 3 4
42.	Characteristics of an electron in an atom (e.g., shells, orbitals)	0 1 2 3 4	0 1 2 3 4
43.	Chemical properties related to electron configuration (e.g., atomic valences and reactivity)	0 1 2 3 4	0 1 2 3 4
44.	Characteristic properties of radiation (e.g., alpha, beta, gamma decay)	0 1 2 3 4	0 1 2 3 4
45.	Artificial and natural radiation	0 1 2 3 4	0 1 2 3 4
46.	Half-life of radioactive isotopes	0 1 2 3 4	0 1 2 3 4
47.	Nuclear reactions (transmutation, fission, fusion)	0 1 2 3 4	0 1 2 3 4
48.	**Overall evaluation of the importance of the Basic Principles of Science**	0 1 2 3 4	

49. How well do the knowledge areas in section B cover the important aspects of Basic Principles of Science?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

C. PHYSICS	IMPORTANCE	LEVEL OF UNDERSTANDING
Mechanics		
50. Relationships among position, velocity, and acceleration for motion in a straight line	0 1 2 3 4	0 1 2 3 4
51. Relationships among position, velocity, and constant acceleration for projectile motion	0 1 2 3 4	0 1 2 3 4
52. Relationships among position, velocity, and centripetal acceleration for uniform circular motion	0 1 2 3 4	0 1 2 3 4
53. Relationship between position and time for periodic motion	0 1 2 3 4	0 1 2 3 4
54. Newton's law of motion	0 1 2 3 4	0 1 2 3 4
55. Relationships among work, energy, and power	0 1 2 3 4	0 1 2 3 4
56. Simple machines, torque	0 1 2 3 4	0 1 2 3 4
57. Friction	0 1 2 3 4	0 1 2 3 4
58. Conservation of momentum	0 1 2 3 4	0 1 2 3 4
59. Conservation of energy	0 1 2 3 4	0 1 2 3 4
60. Newton's law of gravity	0 1 2 3 4	0 1 2 3 4
61. Pascal's principle (hydrostatics)	0 1 2 3 4	0 1 2 3 4
62. Archimedes' principle (buoyancy)	0 1 2 3 4	0 1 2 3 4
63. Bernoulli's principle	0 1 2 3 4	0 1 2 3 4
64. Relativistic effects on length, mass, and time	0 1 2 3 4	0 1 2 3 4
Electricity and Magnetism		
65. Repulsion and attraction of electric charges	0 1 2 3 4	0 1 2 3 4
66. Series and parallel circuits	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

C. PHYSICS (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
67.	Resistance	0 1 2 3 4	0 1 2 3 4
68.	Potential difference	0 1 2 3 4	0 1 2 3 4
69.	Current	0 1 2 3 4	0 1 2 3 4
70.	Capacitance	0 1 2 3 4	0 1 2 3 4
71.	Inductance	0 1 2 3 4	0 1 2 3 4
72.	Direct current (DC) and alternating current (AC)	0 1 2 3 4	0 1 2 3 4
73.	Transformers	0 1 2 3 4	0 1 2 3 4
74.	Motors	0 1 2 3 4	0 1 2 3 4
75.	Sources of EMF (e.g., batteries, solar cells, generators)	0 1 2 3 4	0 1 2 3 4
76.	Large scale generations and transmission of energy and power	0 1 2 3 4	0 1 2 3 4
77.	Semiconductor devices (e.g., diodes, transistors)	0 1 2 3 4	0 1 2 3 4
78.	Magnets	0 1 2 3 4	0 1 2 3 4
79.	Magnetic fields	0 1 2 3 4	0 1 2 3 4
80.	Magnetic forces	0 1 2 3 4	0 1 2 3 4
	Waves		
81.	Wave characteristics (speed, amplitude, wavelength, frequency)	0 1 2 3 4	0 1 2 3 4
82.	Transverse and longitudinal waves	0 1 2 3 4	0 1 2 3 4
83.	Reflection	0 1 2 3 4	0 1 2 3 4
84.	Refraction	0 1 2 3 4	0 1 2 3 4
85.	Diffraction	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE

- **(0) Of no importance**
- **(1) Of little importance**
- **(2) Moderately important**
- **(3) Important**
- **(4) Very important**

LEVEL OF UNDERSTANDING

- **(0) An understanding of the knowledge area is not needed**
- **(1) DEFINE the terms used in the knowledge area**
- **(2) COMPREHEND the essential properties of the knowledge area**
- **(3) APPLY/UTILIZE the knowledge area to address problems or questions**
- **(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts**

C. PHYSICS (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
86. Interference	0 1 2 3 4	0 1 2 3 4
87. Dispersion	0 1 2 3 4	0 1 2 3 4
88. Standing waves and resonance	0 1 2 3 4	0 1 2 3 4
89. Doppler effect	0 1 2 3 4	0 1 2 3 4
90. Characteristics of sound waves (e.g., pitch, loudness, speed, timbre, beats)	0 1 2 3 4	0 1 2 3 4
91. The electromagnetic spectrum (gamma rays to radio waves)	0 1 2 3 4	0 1 2 3 4
92. Color	0 1 2 3 4	0 1 2 3 4
93. Laser light	0 1 2 3 4	0 1 2 3 4
94. Optics (e.g., mirrors, lenses, prisms, fiber optics)	0 1 2 3 4	0 1 2 3 4
95. Polarization	0 1 2 3 4	0 1 2 3 4
96. **Overall evaluation of the importance of Physics**	0 1 2 3 4	

97. How well do the knowledge areas in section C cover the important aspects of Physics?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
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(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D.	CHEMISTRY	IMPORTANCE	LEVEL OF UNDERSTANDING
	Periodicity		
98.	The periodic table	0 1 2 3 4	0 1 2 3 4
99.	The position of solids, liquids, gases, metals, nonmetals, metalloids, and transition elements on the periodic table	0 1 2 3 4	0 1 2 3 4
100.	Trends in melting and boiling temperatures	0 1 2 3 4	0 1 2 3 4
101.	Trends in atomic radii, ionization energy, electron affinity, and electronegativity	0 1 2 3 4	0 1 2 3 4
	The Mole, Chemical Bonding and Molecular Geometry		
102.	Mole concept and conversion among moles, molecules, grams	0 1 2 3 4	0 1 2 3 4
103.	Information conveyed by a chemical formula	0 1 2 3 4	0 1 2 3 4
104.	Simple inorganic nomenclature	0 1 2 3 4	0 1 2 3 4
105.	Classes of organic compounds (i.e., alkanes, alkenes, alcohols, polymers, carbohydrates, proteins, lipids, nucleic acids)	0 1 2 3 4	0 1 2 3 4
106.	Percent composition of elements in a compound	0 1 2 3 4	0 1 2 3 4
107.	Law of constant composition and law of multiple proportions	0 1 2 3 4	0 1 2 3 4
108.	Ionic, covalent, and metallic bonds	0 1 2 3 4	0 1 2 3 4
109.	Electron dot formulas and structural formulas	0 1 2 3 4	0 1 2 3 4
110.	Types of bonding related to electronegativity differences	0 1 2 3 4	0 1 2 3 4
111.	Valence shell electron pair repulsion model (VSEPR)	0 1 2 3 4	0 1 2 3 4
112.	Chemical and physical properties of compounds related to type of bonding and geometry	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D.	CHEMISTRY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
	The Kinetic Theory and States of Matter		
113.	Special properties of water (e.g., density of solid versus liquid, high heat capacity, unusually high boiling temperature)	0 1 2 3 4	0 1 2 3 4
114.	Relationships among phases of matter, forces between particles and particle energy (i.e., shape, volume, diffusion, density, compressibility)	0 1 2 3 4	0 1 2 3 4
115.	Assumptions of the kinetic molecular theory	0 1 2 3 4	0 1 2 3 4
116.	Relationships among volume, pressure, temperature, and quantity for ideal gases	0 1 2 3 4	0 1 2 3 4
117.	Real versus ideal gases	0 1 2 3 4	0 1 2 3 4
118.	Phase changes for a pure substance (e.g., pressure and temperature effects)	0 1 2 3 4	0 1 2 3 4
119.	Relationships among evaporation rate, boiling temperature, and vapor pressure	0 1 2 3 4	0 1 2 3 4
120.	Characteristics of crystals	0 1 2 3 4	0 1 2 3 4
	Chemical Reactions		
121.	Equation balancing from written descriptions of chemical reactions	0 1 2 3 4	0 1 2 3 4
122.	General types of chemical reactions (i.e., composition, decomposition, ionic, replacement)	0 1 2 3 4	0 1 2 3 4
123.	Amounts of reactants and/or products using a balanced chemical equation	0 1 2 3 4	0 1 2 3 4
124.	Endothermic and exothermic reactions	0 1 2 3 4	0 1 2 3 4
125.	Collision theory and reaction rates	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE

- **(0) Of no importance**
- **(1) Of little importance**
- **(2) Moderately important**
- **(3) Important**
- **(4) Very important**

LEVEL OF UNDERSTANDING

- **(0) An understanding of the knowledge area is not needed**
- **(1) DEFINE the terms used in the knowledge area**
- **(2) COMPREHEND the essential properties of the knowledge area**
- **(3) APPLY/UTILIZE the knowledge area to address problems or questions**
- **(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts**

D. CHEMISTRY (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
126.	Activation energy and the effects of a catalyst	0 1 2 3 4	0 1 2 3 4
127.	Rate-influencing factors in chemical reactions (e.g., temperature, pressure, concentration)	0 1 2 3 4	0 1 2 3 4
128.	Chemical equilibrium	0 1 2 3 4	0 1 2 3 4
129.	Le Chatelier's principle	0 1 2 3 4	0 1 2 3 4
130.	Factors that disturb equilibrium (e.g., temperature, pressure, concentration)	0 1 2 3 4	0 1 2 3 4
131.	Oxidation and reduction reactions	0 1 2 3 4	0 1 2 3 4
132.	Electrochemical cells and electrode reactions	0 1 2 3 4	0 1 2 3 4
133.	Practical applications of electrochemistry (e.g., electroplating, lead storage battery, pH meter)	0 1 2 3 4	0 1 2 3 4
	Solutions and Solubility		
134.	Types of solutions (e.g., solid-solid, solid-liquid, liquid-gas)	0 1 2 3 4	0 1 2 3 4
135.	Selective nature of solvents (e.g., like dissolves like)	0 1 2 3 4	0 1 2 3 4
136.	Effects of temperature and pressure on solubility	0 1 2 3 4	0 1 2 3 4
137.	Dissolving process and the factors that effect the rate of dissolving	0 1 2 3 4	0 1 2 3 4
138.	Concentration of solutions (i.e., dilute, concentrated, saturated)	0 1 2 3 4	0 1 2 3 4
139.	Conductivity of solutions and the ionization process	0 1 2 3 4	0 1 2 3 4
140.	Colligative properties of solutions	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
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(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

D. CHEMISTRY (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
141.	Acids, bases, and salts	0 1 2 3 4	0 1 2 3 4
142.	pH	0 1 2 3 4	0 1 2 3 4
143.	Strong *versus* weak acids and bases	0 1 2 3 4	0 1 2 3 4
144.	Buffer solutions	0 1 2 3 4	0 1 2 3 4
145.	**Overall evaluation of the importance of Chemistry**	0 1 2 3 4	

146. How well do the knowledge areas in section D cover the important aspects of Chemistry?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

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_____

E. BIOLOGY			
	The Cell		
147.	Prokaryotic and eukaryotic cells	0 1 2 3 4	0 1 2 3 4
148.	Structure and function of cellular organelles	0 1 2 3 4	0 1 2 3 4
149.	Plant and animal cells	0 1 2 3 4	0 1 2 3 4
150.	Structure and function of membranes (e.g., osmosis, active transport, plasmolysis)	0 1 2 3 4	0 1 2 3 4
151.	Chemical reactions in respiration	0 1 2 3 4	0 1 2 3 4
152.	Chemical reactions in photosynthesis	0 1 2 3 4	0 1 2 3 4
153.	Interrelationships of metabolic pathways	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
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(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E. BIOLOGY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
154. Principles of enzymatic activity	0 1 2 3 4	0 1 2 3 4
155. Cell cycle	0 1 2 3 4	0 1 2 3 4
156. Stages and purposes of mitosis and cytokinesis	0 1 2 3 4	0 1 2 3 4
157. Stages and purposes of meiosis	0 1 2 3 4	0 1 2 3 4
Genetics		
158. Structure and replication of DNA	0 1 2 3 4	0 1 2 3 4
159. Basic mechanisms of protein synthesis	0 1 2 3 4	0 1 2 3 4
160. Causes and results of mutations	0 1 2 3 4	0 1 2 3 4
161. Genetic engineering	0 1 2 3 4	0 1 2 3 4
162. Mendel's Laws and monohybrid and dihybrid crosses	0 1 2 3 4	0 1 2 3 4
163. Non-Mendelian inheritance (e.g., multiple alleles, multiple genes)	0 1 2 3 4	0 1 2 3 4
164. Interaction between heredity and environment	0 1 2 3 4	0 1 2 3 4
165. Human genetic disorders	0 1 2 3 4	0 1 2 3 4
Evolution		
166. Historical developments relating to the origin of life (e.g., spontaneous generation, experiments by Redi, Pasteur, Oparin, Miller)	0 1 2 3 4	0 1 2 3 4
167. Evidence for and factors affecting evolution	0 1 2 3 4	0 1 2 3 4
168. Theories and patterns of evolution	0 1 2 3 4	0 1 2 3 4
169. Isolating mechanisms and speciation	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

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(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E.	BIOLOGY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
	Diversity of Life		
170.	General characteristics of life	0 1 2 3 4	0 1 2 3 4
171.	Classification schemes (Five Kingdoms and nomenclature)	0 1 2 3 4	0 1 2 3 4
172.	Characteristics of viruses, monerans, protists, fungi, plants and animals	0 1 2 3 4	0 1 2 3 4
	Plants		
173.	Nonvascular and vascular plants	0 1 2 3 4	0 1 2 3 4
174.	Structure and functions of roots, stems, and leaves	0 1 2 3 4	0 1 2 3 4
175.	Transport systems, nutrient uptake	0 1 2 3 4	0 1 2 3 4
176.	Control mechanisms (e.g., hormones, photoperiods, tropisms)	0 1 2 3 4	0 1 2 3 4
177.	Asexual reproduction	0 1 2 3 4	0 1 2 3 4
178.	Sexual reproduction (flowers, fruits, seeds, dispersal, germination)	0 1 2 3 4	0 1 2 3 4
	Animals		
179.	Digestion and nutrition	0 1 2 3 4	0 1 2 3 4
180.	Circulation	0 1 2 3 4	0 1 2 3 4
181.	Respiration	0 1 2 3 4	0 1 2 3 4
182.	Excretion	0 1 2 3 4	0 1 2 3 4
183.	Nervous system	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
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(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

E.	BIOLOGY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
184.	Musculoskeletal system	0 1 2 3 4	0 1 2 3 4
185.	Immune and lymphatic systems	0 1 2 3 4	0 1 2 3 4
186.	Endocrine system	0 1 2 3 4	0 1 2 3 4
187.	Reproduction and development	0 1 2 3 4	0 1 2 3 4
188.	Homeostasis	0 1 2 3 4	0 1 2 3 4
189.	Responses to stimuli (taxes, instincts, conditioned reflexes, learned behaviors)	0 1 2 3 4	0 1 2 3 4
	Ecology		
190.	Population dynamics (intraspecific interaction)	0 1 2 3 4	0 1 2 3 4
191.	Life-history patterns (e.g., r and k strategists)	0 1 2 3 4	0 1 2 3 4
192.	Interspecific relationships (e.g., commensalism, mutualism, competition, predation, parasitism)	0 1 2 3 4	0 1 2 3 4
193.	Community structure and niche	0 1 2 3 4	0 1 2 3 4
194.	Social behavior (e.g., dominance, hierarchy, altruism)	0 1 2 3 4	0 1 2 3 4
195.	Species diversity in communities	0 1 2 3 4	0 1 2 3 4
196.	Succession	0 1 2 3 4	0 1 2 3 4
197.	Aquatic and terrestrial ecosystems	0 1 2 3 4	0 1 2 3 4
198.	Food webs and energy flow through ecosystems	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

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E. BIOLOGY (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
199.	Cycling of materials (e.g., nitrogen, water, carbon)	0 1 2 3 4	0 1 2 3 4
200.	Biomes	0 1 2 3 4	0 1 2 3 4
201.	**Overall evaluation of the importance of Biology**	0 1 2 3 4	

202. How well do the knowledge areas in section E cover the important aspects of Biology?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

F. EARTH AND SPACE SCIENCE

Physical Geology

		IMPORTANCE	LEVEL OF UNDERSTANDING
203.	Physical and chemical properties of minerals (e.g., density, hardness, response to acid test, identification)	0 1 2 3 4	0 1 2 3 4
204.	General types of minerals (e.g., silicates, carbonates)	0 1 2 3 4	0 1 2 3 4
205.	Types of rocks and the processes that form them (sedimentary, igneous, and metamorphic rocks)	0 1 2 3 4	0 1 2 3 4
206.	Folding and faulting	0 1 2 3 4	0 1 2 3 4
207.	Earthquakes	0 1 2 3 4	0 1 2 3 4
208.	Volcanoes	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
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(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

F. EARTH AND SPACE SCIENCE (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
209.	Rock magnetism	0 1 2 3 4	0 1 2 3 4
210.	Isostasy	0 1 2 3 4	0 1 2 3 4
211.	Evidence from seismic studies (e.g., oil exploration, crustal depth)	0 1 2 3 4	0 1 2 3 4
212.	Crust, mantle, and core	0 1 2 3 4	0 1 2 3 4
213.	Lithosphere and asthenosphere	0 1 2 3 4	0 1 2 3 4
214.	Convection in the mantle	0 1 2 3 4	0 1 2 3 4
215.	Heat sources within the Earth	0 1 2 3 4	0 1 2 3 4
216.	Hot spots	0 1 2 3 4	0 1 2 3 4
217.	Plate tectonic theory	0 1 2 3 4	0 1 2 3 4
218.	Physical and chemical weathering	0 1 2 3 4	0 1 2 3 4
219.	Mass wasting (e.g., creep, slump)	0 1 2 3 4	0 1 2 3 4
220.	Hydrologic cycle	0 1 2 3 4	0 1 2 3 4
221.	Artesian and nonartesian wells	0 1 2 3 4	0 1 2 3 4
222.	Process and structures of erosional/depositional features shaped by running water, ground water, wind, and glaciers	0 1 2 3 4	0 1 2 3 4
	Historical Geology		
223.	Principle of uniformitarianism	0 1 2 3 4	0 1 2 3 4
224.	Relative and absolute time (including dating techniques)	0 1 2 3 4	0 1 2 3 4
225.	Geologic time scale	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
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F.	EARTH AND SPACE SCIENCES (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
226.	Principles of stratigraphy (e.g., cross relations, superposition, fossil assemblages, correlation)	0 1 2 3 4	0 1 2 3 4
227.	Formation of atmosphere and hydrosphere	0 1 2 3 4	0 1 2 3 4
228.	Types of fossils and evidence provided by fossils	0 1 2 3 4	0 1 2 3 4
229.	Mass extinctions	0 1 2 3 4	0 1 2 3 4
	Oceanography		
230.	Wind-generated waves (e.g., formation, motion)	0 1 2 3 4	0 1 2 3 4
231.	Tides	0 1 2 3 4	0 1 2 3 4
232.	Ocean currents (global and local; surface and deep)	0 1 2 3 4	0 1 2 3 4
233.	Shore processes (e.g., formation of dunes, beach profiles, wave effects)	0 1 2 3 4	0 1 2 3 4
234.	Geographic location of oceans and seas	0 1 2 3 4	0 1 2 3 4
235.	Physical and chemical properties of the oceans	0 1 2 3 4	0 1 2 3 4
236.	Topography of the ocean floor	0 1 2 3 4	0 1 2 3 4
237.	Effects of plate tectonics on the geology, biology, and topography of the ocean floor	0 1 2 3 4	0 1 2 3 4
238.	Nutrient cycles of the ocean	0 1 2 3 4	0 1 2 3 4
	Meteorology		
239.	Physical and chemical properties of atmospheric layers	0 1 2 3 4	0 1 2 3 4
240.	Seasonal and latitudinal variation of solar radiation	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

F. EARTH AND SPACE SCIENCES (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
241.	Heat budget of the atmosphere and the natural greenhouse effect	0 1 2 3 4	0 1 2 3 4
242.	Causes of winds	0 1 2 3 4	0 1 2 3 4
243.	Global wind belts	0 1 2 3 4	0 1 2 3 4
244.	Variations in circulation (e.g., sea and land breezes, monsoons, jet stream, temperature inversions)	0 1 2 3 4	0 1 2 3 4
245.	Relative and absolute humidity (e.g., dew, frost point)	0 1 2 3 4	0 1 2 3 4
246.	Cloud types and formation	0 1 2 3 4	0 1 2 3 4
247.	Precipitation types and formation	0 1 2 3 4	0 1 2 3 4
248.	Air masses (e.g., temperature, moisture content, source areas)	0 1 2 3 4	0 1 2 3 4
249.	High and low pressure systems (including storms)	0 1 2 3 4	0 1 2 3 4
250.	Frontal systems (e.g., cold, warm, stationary, occluded) and associated weather	0 1 2 3 4	0 1 2 3 4
251.	Weather maps and station models	0 1 2 3 4	0 1 2 3 4
252.	Weather forecasting	0 1 2 3 4	0 1 2 3 4
253.	Regional and local natural factors affecting climate (e.g., topography, rainfall, latitude)	0 1 2 3 4	0 1 2 3 4
254.	Desertification, enhanced greenhouse effect, volcanic ash effects on climate	0 1 2 3 4	0 1 2 3 4
	Astronomy		
255.	Theories of and evidence for the origin of the universe	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE

- **(0) Of no importance**
- **(1) Of little importance**
- **(2) Moderately important**
- **(3) Important**
- **(4) Very important**

LEVEL OF UNDERSTANDING

- **(0) An understanding of the knowledge area is not needed**
- **(1) DEFINE the terms used in the knowledge area**
- **(2) COMPREHEND the essential properties of the knowledge area**
- **(3) APPLY/UTILIZE the knowledge area to address problems or questions**
- **(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts**

F. EARTH AND SPACE SCIENCES (cont.)		IMPORTANCE	LEVEL OF UNDERSTANDING
256.	Structure of the universe (e.g., galaxies, novas, black holes, quasars, stars)	0 1 2 3 4	0 1 2 3 4
257.	Large units of distance (e.g., astronomical unit, light-year, parsec)	0 1 2 3 4	0 1 2 3 4
258.	Origin and life cycle of stars	0 1 2 3 4	0 1 2 3 4
259.	Origin of the solar system	0 1 2 3 4	0 1 2 3 4
260.	Major features of the Sun (including its energy source)	0 1 2 3 4	0 1 2 3 4
261.	Structure of the solar system (e.g., planets, moons, asteroids, comets)	0 1 2 3 4	0 1 2 3 4
262.	Phases of the Moon	0 1 2 3 4	0 1 2 3 4
263.	Lunar and solar eclipses	0 1 2 3 4	0 1 2 3 4
264.	Causes of seasons	0 1 2 3 4	0 1 2 3 4
265.	Factors determining the length of a planetary year and day	0 1 2 3 4	0 1 2 3 4
266.	Time zones on the Earth	0 1 2 3 4	0 1 2 3 4
267.	Space exploration	0 1 2 3 4	0 1 2 3 4
268.	Exploration of Earth from space	0 1 2 3 4	0 1 2 3 4
269.	**Overall evaluation of the importance of Earth and Space Sciences**	0 1 2 3 4	

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE		LEVEL OF UNDERSTANDING	
(0)	Of no importance	(0)	An understanding of the knowledge area is not needed
(1)	Of little importance	(1)	DEFINE the terms used in the knowledge area
(2)	Moderately important	(2)	COMPREHEND the essential properties of the knowledge area
(3)	Important	(3)	APPLY/UTILIZE the knowledge area to address problems or questions
(4)	Very important	(4)	ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

F. EARTH AND SPACE SCIENCES (cont.)

270. How well do the knowledge areas in section F cover the important aspects of Earth and Space Sciences?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

G. SCIENCE, TECHNOLOGY, AND SOCIETY		IMPORTANCE	LEVEL OF UNDERSTANDING
271.	Issues associated with energy production and use . . .	0 1 2 3 4	0 1 2 3 4
272.	Issues associated with production and use of consumer products	0 1 2 3 4	0 1 2 3 4
273.	Problems caused by the biological magnification of toxic materials in food chains	0 1 2 3 4	0 1 2 3 4
274.	Conservation of nonrenewable resources (e.g., soil, water, metals, and fossil fuels)	0 1 2 3 4	0 1 2 3 4
275.	Relationship of geographic distribution of natural resources, population patterns, and global politics, (including habitat destruction)	0 1 2 3 4	0 1 2 3 4
276.	Issues associated with biotechnology (e.g., gene cloning, in vitro fertilization, prolonging life, birth control, prenatal testing, abortion, radiation, use of hormones in agriculture)	0 1 2 3 4	0 1 2 3 4
277.	Biological and chemical control of agricultural pests	0 1 2 3 4	0 1 2 3 4
278.	Effect of agricultural practice on the environment . .	0 1 2 3 4	0 1 2 3 4

Evaluate each knowledge area in terms of IMPORTANCE for and LEVEL OF UNDERSTANDING needed by newly licensed (certified) teachers of general science courses (also including physical science courses, life science courses, and earth science courses, primarily grades 7-9) if they are to perform their job in a competent manner.

IMPORTANCE	LEVEL OF UNDERSTANDING
(0) Of no importance	(0) An understanding of the knowledge area is not needed
(1) Of little importance	(1) DEFINE the terms used in the knowledge area
(2) Moderately important	(2) COMPREHEND the essential properties of the knowledge area
(3) Important	(3) APPLY/UTILIZE the knowledge area to address problems or questions
(4) Very important	(4) ANALYZE the knowledge area into component parts and explain the interrelationships among the parts

G. SCIENCE, TECHNOLOGY, AND SOCIETY (cont.)	IMPORTANCE	LEVEL OF UNDERSTANDING
279. Use of science and technology to predict and prepare for natural disasters (e.g., earthquakes, volcanic eruptions, floods, severe weather patterns)	0 1 2 3 4	0 1 2 3 4
280. Use of technology in everyday devices (e.g., lamp, smoke detector, refrigerator)	0 1 2 3 4	0 1 2 3 4
281. Issues associated with health and wellness	0 1 2 3 4	0 1 2 3 4
282. Issues associated with technology transfer (e.g., space technology, superconductors)	0 1 2 3 4	0 1 2 3 4
283. **Overall evaluation of the importance of Science, Technology, and Society**	0 1 2 3 4	

284. How well do the knowledge areas in section G cover the important aspects of Science, Technology, and Society?

1	2	3	4	5
Very Poorly	Poorly	Adequately	Well	Very Well

What important aspects, if any, are not covered?

_____

_____

PART II - RECOMMENDATIONS FOR MODULE CONTENT

Listed below are seven broad topics that may be covered on the module for general science. If the module contained 100 questions, how many questions should be included from each topic? If you feel a category should not be included in the module, put 0 in the space provided. Make sure your responses sum to 100.

	TOPICS	NUMBER OF MODULE QUESTIONS (out of 100)
285.	SCIENTIFIC METHODOLOGY/TECHNIQUES/ HISTORY	_____
286.	BASIC PRINCIPLES OF SCIENCE	_____
287.	PHYSICS	_____
288.	CHEMISTRY	_____
289.	BIOLOGY	_____
290.	EARTH AND SPACE SCIENCE	_____
291.	SCIENCE, TECHNOLOGY, AND SOCIETY	_____
	TOTAL	100

PART III - BACKGROUND INFORMATION

The information that you provide in this section is completely confidential and will be used for research purposes only. Please answer the questions by circling the number that most closely describes you or your professional activities. Unless otherwise indicated, please circle only one response for each question.

292. Where do you work?

1. Alabama
2. Alaska
3. Arizona
4. Arkansas
5. California
6. Colorado
7. Connecticut
8. Delaware
9. District of Columbia
10. Florida
11. Georgia
12. Hawaii
13. Idaho
14. Illinois
15. Indiana
16. Iowa
17. Kansas
18. Kentucky
19. Louisiana
20. Maine
21. Maryland
22. Massachusetts
23. Michigan
24. Minnesota
25. Mississippi
26. Missouri
27. Montana
28. Nebraska
29. Nevada
30. New Hampshire
31. New Jersey
32. New Mexico
33. New York
34. North Carolina
35. North Dakota
36. Ohio
37. Oklahoma
38. Oregon
39. Pennsylvania
40. Puerto Rico
41. Rhode Island
42. South Carolina
43. South Dakota
44. Tennessee
45. Texas
46. Utah
47. Vermont
48. Virginia
49. Washington
50. West Virginia
51. Wisconsin
52. Wyoming

293. What is your age?

1. Under 25
2. 25-34
3. 35-44
4. 45-54
5. 55-64
6. Over 64

294. What is your sex?

1. Female
2. Male

295. Which of the following best describes the area in which you work?

1. Urban
2. Suburban
3. Rural

296. How do you describe yourself?

1. Native American, American Indian, or Alaskan Native
2. Asian American, Asian, Native Hawaiian, or Pacific Islander
3. African American or Black
4. Mexican American or Chicano
5. Puerto Rican
6. Latin American, South American, Central American, or other Hispanic
7. White
8. Other

297. Which of the following best describes your highest educational attainment?

1. Less than a bachelor's
2. Bachelor's
3. Bachelor's + additional credits
4. Master's
5. Master's + additional credits
6. Doctorate

298. Which of the following best describes your current employment status?

1. Temporary substitute (assigned on a daily basis)
2. Permanent substitute (assigned on a longer term basis)
3. Regular teacher (not a substitute)
4. Principal or assistant principal
5. School administrator
6. Curriculum supervisor
7. State administrator
8. College faculty
9. Other (please specify)_____

299. How many years have you taught general science?

1. Never taught general science
2. Less than a year
3. 1 - 2 years
4. 3 - 5 years
5. 6 - 10 years
6. 11 - 15 years
7. 16 - 20 years
8. 21 or more years

300. What grade level(s) are you currently teaching? (Circle all that apply)

1. Preschool/Kindergarten
2. Grades 1-4
3. Grades 5-8
4. Grades 9-12
5. College
6. Do not teach
7. Other (please specify)_____

301. Which of the following describes your current teaching assignment? (Circle all that apply)?

1. Biology
2. Earth and Space Science
3. Ecology
4. General Science
5. Marine Science
6. Physical Science
7. Physics
8. Chemistry
9. College
10. Do not teach
11. Other (please specify)_____

302. Circle the following organizations to which you belong.

1. American Association of Physics Teachers
2. American Association for the Advancement of Science
3. American Chemical Society
4. American Federation of Teachers
5. National Association of Biology Teachers
6. National Association for Research in Science Teaching
7. National Science Supervisors Association
8. National Science Teachers Association
9. National Association for Science, Technology, and Society
10. National Education Association
11. Other (please specify)_____

THANK YOU FOR COMPLETING THIS INVENTORY.
PLEASE RETURN IT WITHIN 10 DAYS USING THE ENCLOSED ENVELOPE.

Appendix Ç

Survey Cover Letter

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

609-921-9000
609-734-1090 (Fax)
CABLE-EDUCTESTSVC

DIVISION OF APPLIED
MEASUREMENT RESEARCH

October 1990

Dear Colleague:

I am writing to ask your cooperation in a project that should be of importance to teachers, college faculty, administrators, and other professionals in your field. Educational Testing Service (ETS) is in the process of developing a new generation of assessments for the purpose of licensing teachers. One type of assessment will be created to measure the prospective teacher's subject-matter of specialty-area knowledge and will likely be administered upon completion of the undergraduate teacher education program. One such assessment is a General Science module. I am asking for your help as we develop this module.

As part of the developmental process, ETS has worked closely with an advisory committee of classroom teachers, college faculty, and school administrators to identify potentially important knowledge areas in general science instruction. The enclosed inventory has been constructed as a way to obtain your judgments of the importance of these areas for the newly licensed (certified) teachers of general science courses. Your responses and those of other professionals to this inventories will guide the development of the module.

You will notice that the inventory asks for some background information about you; this is solely for purposes of describing respondents. **Your answers will be treated in strict confidence.**

A postage-paid envelope is enclosed for the return of your completed inventory. Thank you for your participation in this very important project.

Sincerely,

Richard Tannenbaum, Ph.D.
Associate Research Scientist

Enclosures (2)

Appendix D

Respondent Demographic

	Number	Percent
GEOGRAPHIC REGION		
Northeast	46	26.1
Central	48	27.3
Southern	55	31.3
Far West	27	15.3
Total	176	
Missing Responses	2	
AGE (years)		
Under 25	1	0.6
25 - 34	28	16.0
35 - 44	73	41.7
45 - 54	48	27.4
55 - 64	21	12.0
Over 64	4	2.3
Total	175	
Missing Responses	3	
SEX		
Female	81	46.0
Male	95	54.0
Total	176	
Missing Responses	2	
SCHOOL SETTING		
Urban	44	25.3
Suburban	67	38.5
Rural	63	36.2
Total	174	
Missing Responses	4	

	Number	Percent
RACE/ETHNICITY		
Native American	6	3.4
Asian American	3	1.7
Black	9	5.1
Mexican American	0	0.0
Puerto Rican	1	0.6
Hispanic	1	0.6
White	154	88.0
Other	1	0.6
Total	175	
Missing Responses	3	
HIGHEST EDUCATIONAL ATTAINMENT		
Less than Bachelor's	0	0.0
Bachelor's	5	2.9
Bachelor's + Credits	55	31.4
Master's	15	8.6
Master's + Credits	81	46.3
Doctorate	19	10.9
Total	175	
Missing Responses	3	
CURRENT EMPLOYMENT STATUS		
Temporary Substitute	0	0.0
Permanent Substitute	0	0.0
Regular Teacher (not a substitute)	119	70.4
Principal/Assistant Principal	0	0.0
School Administrator	0	0.0
Curriculum Supervisor	11	6.5
State Administrator	1	0.6
College Faculty	33	19.5

	Number	Percent
CURRENT EMPLOYMENT STATUS (cont.)		
Other	5	3.0
Total	169	
Missing Responses	9	
TEACHING EXPERIENCE (years)		
Never taught	23	13.1
Less than 1	1	0.6
1 - 2	12	6.9
3 - 5	23	13.1
6 - 10	28	16.0
11 - 15	30	17.1
16 - 20	35	20.0
21 or more	23	13.1
Total	175	
Missing Responses	3	
GRADES CURRENTLY TEACHING[1]		
Preschool/Kindergarten	2	1.0
Grades 1 - 4	2	1.0
Grades 5 - 8	77	38.7
Grades 9 - 12	61	30.7
College	37	18.6
Do Not Teach	9	4.5
Other	11	5.5
Total	199	
CURRENT TEACHING ASSIGNMENT[1]		
Biology	68	15.6
Earth and Space Science	47	10.8
Ecology	24	5.5

	Number	Percent
CURRENT TEACHING ASSIGNMENT (cont.)		
General Science	85	19.5
Marine Science	4	0.9
Physical Science	56	12.9
Physics	27	6.2
Chemistry	42	9.7
College	27	6.2
Do Not Teach	8	1.8
Other	47	10.8
Total	435	
MEMBERSHIP IN ORGANIZATIONS[1]		
American Association of Physics Teachers	12	4.0
American Association for the Advancement of Science	16	5.3
American Chemical Society	15	5.0
American Federation of Teachers	9	3.0
National Association of Biology Teachers	13	4.3
National Association for Research in Science Teaching	5	1.7
National Science Supervisors Association	17	5.6
National Science Teachers Association	71	23.5
National Association for Science, Technology, and Society	7	2.3
National Educational Association	74	24.5
Other	63	20.9
Total	302	

[1] NOTE: Multiple responses were permitted. Hence, the total will exceed 178 and 100%.

Appendix E

Mean Importance Ratings by Teachers and Teacher Educators

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
Methodology and Philosophy					
1	Scientific methods (e.g., formulation of problem, hypotheses, etc.)	3.72	0.49	3.55	0.71
2	Facts, models, theories, and laws	3.16	0.77	3.15	0.71
3	Design of experiments (e.g., controls, independent/dependent variables)	3.43	0.73	3.15	0.87
4	Observations, interpretations, and inferences	3.41	0.77	3.24	0.71
5	Qualitative and quantitative observations	3.18	0.85	3.09	0.63
6	History of science, including contributions of various cultures	2.34	0.90	2.52	0.87
Mathematics, Measurement, and Data Manipulation					
7	The metric systems	3.55	0.65	3.73	0.63
8	Scientific notation	2.80	0.97	3.27	0.80
9	Significant figures in measurement and calculations	2.61	1.01	3.03	0.85
10	Unit/dimensional analysis	2.49	1.08	2.84	1.11
11	Experimental errors (e.g., sources, precision, accuracy)	2.38	1.00	2.67	0.82
12	Measures of central tendency and dispersion(e.g., mean, median, S.D., range)	1.93	1.08	2.39	1.03
13	Mathematical relationships and patterns in numerical data	1.89	1.12	2.67	0.92
14	Simple digital (binary) logic	1.88	1.15	2.15	0.94
15	Presentation and interpretation of data in tables, graphs, charts, and maps	3.53	0.69	3.55	0.56
Laboratory, Field Activities, and Safety					
16	Laboratory and field equipment (e.g., balances, scales, ammeters, etc.)	3.66	0.59	3.42	0.71
17	Preparation of specimens and materials (e.g., biological specimens, mixtures)	3.08	0.92	3.12	0.60
18	Safety procedures	3.91	0.34	3.76	0.44
19	Laboratory and field hazards	3.68	0.64	3.73	0.52
20	Storage and disposal of materials	3.60	0.71	3.64	0.60
B. BASIC PRINCIPLES OF SCIENCE					
23	Physical and chemical properties	3.36	0.64	3.39	0.56
24	Particulate nature of matter	3.44	0.64	3.39	0.61
25	Elements, names, symbols, occurrence, and relative abundance	3.10	0.77	3.03	0.73
26	Physical and chemical changes	3.32	0.67	3.24	0.66
27	Conservation of mass/energy	3.17	0.79	3.30	0.68
28	Forms of energy	3.34	0.69	3.03	0.59
29	Energy transformations	3.03	0.80	3.09	0.63

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		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
B. BASIC PRINCIPLES OF SCIENCE (cont.)					
Heat and Thermodynamics					
30	Heat versus temperature	2.76	0.77	2.97	0.86
31	Temperature scales and measurement	3.22	0.69	3.00	0.71
32	Conduction, convection, and radiation	2.99	0.83	2.91	0.80
33	Heat capacity/thermal exchange/heat of fusion and vaporization	2.52	0.88	2.55	1.03
34	Phase changes	3.13	0.80	2.91	0.88
35	Expansion and contraction	2.93	0.79	2.75	0.80
36	First law of thermodynamics	2.58	0.92	2.75	0.98
37	Second law of thermodynamics	2.47	0.92	2.66	1.07
Atomic and Nuclear Structure					
38	Historical development of atomic models	2.34	0.98	2.36	0.99
39	Structure of the atom	3.51	0.70	3.45	0.67
40	Atomic mass, atomic number, mass number, and isotopes	3.23	0.84	3.30	0.73
41	Nuclear forces and binding energy	2.47	0.83	2.52	0.87
42	Characteristics of an electron in an atom	2.88	0.98	2.82	0.85
43	Chemical properties related to electron configuration	2.55	1.04	2.82	1.01
44	Chemical properties of radiation (e.g., alpha, beta, gamma decay)	2.27	1.06	2.48	0.83
45	Artificial and natural radiation	2.26	1.00	2.33	0.74
46	Half-life of radioactive isotopes	2.16	0.99	2.33	0.89
47	Nuclear reactions	2.58	1.01	2.27	0.88
C. PHYSICS					
Mechanics					
50	Relationships among position/velocity/acceleration for motion in a straight line	2.79	0.93	3.00	0.79
51	Rel. among position/velocity/constant acceleration for projectile motion	2.51	0.95	2.80	0.85
52	Rel. among position/velocity/centripetal acceleration for uniform circular motion	2.41	0.98	2.90	0.80
53	Relationship between position and time for periodic motion	2.25	0.97	2.57	0.82
54	Newton's law of motion	3.25	0.78	3.37	0.67
55	Relationships among work, energy, and power	3.19	0.80	3.07	0.74
56	Simple machines, torque	2.97	0.85	3.03	0.78
57	Friction	3.08	0.83	3.03	0.72
58	Conservation of momentum	2.68	0.93	3.03	0.61

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
C. PHYSICS (cont.)					
59	Conservation of energy	3.11	0.82	3.40	0.67
60	Newton's law of gravity	3.22	0.74	3.27	0.74
61	Pascal's principle (hydrostatics)	2.07	1.09	2.53	0.68
62	Archimedes' principle (buoyancy)	2.43	0.97	2.67	0.76
63	Bernoulli's principle	2.40	0.98	2.43	0.97
64	Relativistic effects on length, mass, and time	2.36	1.09	2.13	1.01
Electricity and Magnetism					
65	Repulsion and attraction of electric charges	3.25	0.82	3.23	0.90
66	Series and parallel circuits	3.09	0.92	2.83	0.99
67	Resistance	2.71	0.97	3.03	0.73
68	Potential difference	2.44	1.00	2.83	0.85
69	Current	2.89	0.98	3.03	0.73
70	Capacitance	2.01	0.96	2.48	0.99
71	Inductance	2.05	0.98	2.34	0.94
72	Direct current (DC) and alternating current (AC)	2.95	0.94	3.00	0.76
73	Transformers	2.45	0.94	2.69	0.76
74	Motors	2.56	0.97	2.76	0.83
75	Sources of EMF (e.g., batteries, solar cells, generators)	2.79	0.91	2.93	0.80
76	Large scale generations and transmission of energy and power	2.44	1.04	2.24	0.83
77	Semiconductor devices (e.g., diodes, transistors)	2.23	1.00	2.38	0.98
78	Magnets	3.09	0.84	3.07	0.70
79	Magnetic fields	2.92	0.93	2.93	0.80
80	Magnetic forces	2.89	0.95	2.83	0.89
Waves					
81	Wave characteristics (speed, amplitude, wavelength, frequency)	3.06	0.88	3.14	0.83
82	Transverse and longitudinal waves	2.86	0.95	2.79	0.90
83	Reflection	3.03	0.85	2.93	0.88
84	Refraction	3.02	0.83	2.90	0.86
85	Diffraction	2.74	0.92	2.62	1.05
86	Interference	2.34	1.04	2.28	1.07
87	Dispersion	2.21	1.06	2.03	1.02

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
C. PHYSICS (cont.)					
88	Standing waves and resonance	2.20	1.01	2.41	0.87
89	Doppler effect	2.72	0.95	2.55	0.95
90	Characteristics of sound waves (e.g., pitch, loudness, speed, timbre, beats)	2.82	0.96	2.64	0.91
91	The electromagnetic spectrum (gamma rays to radio waves)	2.90	0.95	3.10	0.90
92	Color	3.03	0.85	2.86	0.83
93	Laser light	2.70	0.87	2.72	0.80
94	Optics (e.g., mirrors, lenses, prisms, fiber optics)	2.91	0.86	3.03	0.91
95	Polarization	2.39	0.90	2.41	0.98
D. CHEMISTRY					
Periodicity					
98	The periodic table	3.37	0.78	3.25	0.95
99	The position of solids, liquids, etc. on the periodic table	3.01	0.89	2.94	1.01
100	Trends in melting and boiling temperatures	2.50	0.90	2.37	1.03
101	Trends in atomic radii, ionization energy, electron affinity, and electronegativity	2.15	1.05	2.10	1.11
The Mole, Chemical Bonding and Molecular Geometry					
102	Mole concept and conversion among moles, molecules, grams	2.09	1.20	2.77	1.01
103	Information conveyed by a chemical formula	3.10	0.96	3.20	0.81
104	Simple inorganic nomenclature	2.63	1.11	3.00	0.87
105	Classes of organic compounds (i.e., alkanes, alkenes, alcohols)	2.19	1.12	2.67	1.06
106	Percent composition of elements in a compound	2.34	1.12	2.73	1.01
107	Law of constant composition and law of multiple proportions	2.09	1.11	2.67	1.12
108	Ionic, covalent, and metallic bonds	2.69	1.10	3.17	0.87
109	Electron dot formulas and structural formulas	2.46	1.16	2.57	0.94
110	Types of bonding related to electronegativity differences	1.99	1.11	2.17	1.05
111	Valence shell electron pair repulsion model (VSEPR)	1.83	1.22	1.97	0.89
112	Chem./physical properties of compounds related to type of bonding/geometry	2.04	1.14	2.20	0.85
The Kinetic Theory and States of Matter					
113	Special properties of water (e.g., density of solid versus liquid)	2.71	1.02	2.87	1.01
114	Rel. among phases of matter, forces between particles and particle energy	2.61	1.06	2.57	1.01
115	Assumptions of the kinetic molecular theory	2.41	1.07	2.47	0.82
116	Relationships among volume/pressure/temperature/quantity for ideal gases	2.54	1.00	2.86	1.06

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
D. CHEMISTRY (cont.)					
117	Real versus ideal gases	1.86	1.07	2.10	1.12
118	Phase changes for a pure substance	2.27	1.03	2.43	1.07
119	Relationships among evaporation rate/boiling temperature/vapor pressure	2.38	1.05	2.43	0.94
120	Characteristics of crystals	2.24	0.93	2.23	0.82
Chemical Reactions					
121	Equation balancing from written description of chemical reaction	2.74	1.08	2.87	1.17
122	General types of chemical reactions	2.72	1.10	2.90	1.03
123	Amounts of reactants and/or products using a balanced chemical equation	2.49	1.11	2.60	1.04
124	Endothermic and exothermic reactions	2.41	1.11	2.53	1.01
125	Collision theory and reaction rates	1.91	1.08	2.00	1.11
126	Activation energy and the effects of a catalyst	2.09	1.14	2.39	0.99
127	Rate-influencing factors in chemical reactions	2.35	1.07	2.58	0.96
128	Chemical equilibrium	2.26	1.14	2.52	1.03
129	Le Châtelier's principle	1.71	1.08	2.10	1.16
130	Factors that disturb equilibrium (e.g., temperature, pressure, concentration)	2.11	1.19	2.35	1.02
131	Oxidation and reduction reactions	2.28	1.10	2.52	1.00
132	Electrochemical cells and electrode reactions	2.02	0.96	2.32	0.83
133	Practical applications of electrochemistry	2.16	1.09	2.63	0.85
Solutions and Solubility					
134	Types of solutions	2.86	0.98	2.71	1.01
135	Selective nature of solvents (e.g., like dissolves like)	2.51	1.02	2.77	0.99
136	Effects of temperature and pressure on solubility	2.66	0.98	2.55	0.89
137	Dissolving process and the factors that effect the rate of dissolving	2.55	1.01	2.45	0.96
138	Concentration of solutions	2.88	0.87	2.81	0.91
139	Conductivity of solutions and the ionization process	2.37	1.01	2.42	0.92
140	Colligative properties of solutions	1.94	1.05	2.10	1.03
141	Acids, bases, and salts	3.22	0.82	3.29	0.74
142	pH	3.14	0.83	3.16	0.90
143	Strong versus weak acids and bases	2.84	0.94	2.90	0.87
144	Buffer solutions	2.46	0.99	2.68	1.05

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
E. BIOLOGY					
The Cell					
147	Prokaryotic and eukaryotic cells	2.45	1.16	2.92	1.22
148	Structure and functions of cellular organelles	2.83	0.98	3.00	1.12
149	Plant and animal cells	3.41	0.70	3.27	0.67
150	Structure and function of membranes (e.g., active transport, plasmolysis)	2.97	0.87	3.15	0.88
151	Chemical reactions in respiration	2.69	1.01	2.96	0.87
152	Chemical reactions in photosynthesis	2.88	1.00	3.08	0.84
153	Interrelationships of metabolic pathways	2.19	1.15	2.73	1.12
154	Principles of enzymatic activity	2.16	1.07	2.80	0.96
155	Cell cycle	2.65	1.13	3.12	0.82
156	Stages and purposes of mitosis and cytokinesis	2.80	0.94	3.12	0.95
157	Stages and purposes of meiosis	2.82	0.92	3.08	1.06
Genetics					
158	Structure and replication of DNA	2.79	0.91	3.23	0.91
159	Basic mechanisms of protein synthesis	2.36	1.05	2.85	1.08
160	Causes and results of mutations	2.59	1.05	2.77	1.03
161	Genetic engineering	2.48	1.04	2.50	1.10
162	Mendel's Laws and monohybrid and dihybrid crosses	2.94	0.97	2.88	0.99
163	Non-Mendelian inheritance (e.g., multiple alleles, multiple genes)	2.52	0.98	2.58	1.17
164	Interaction between heredity and environment	2.96	0.87	2.92	0.93
165	Human genetic disorders	2.86	0.95	2.73	1.00
Evolution					
166	Historical developments relating to the origin of life	2.60	1.08	2.73	0.96
167	Evidence for and factors affecting evolution	2.59	1.15	3.04	0.79
168	Theories and patterns of evolution	2.65	1.18	2.69	0.97
169	Isolating mechanisms and speciation	2.26	1.11	2.46	1.07
Diversity of Life					
170	General characteristics of life	3.47	0.71	3.27	0.78
171	Classification schemes (Five Kingdoms and nomenclature)	3.23	0.80	3.00	0.94
172	Characteristics of viruses, monerans, protists, fungi, plants and animals	3.17	0.83	2.92	0.98

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
E. BIOLOGY (cont.)					
Plants					
173	Nonvascular and vascular plants	2.97	0.85	2.92	0.93
174	Structure and functions of roots, stems, and leaves	3.21	0.71	3.31	0.62
175	Transport systems, nutrient uptake	2.87	0.95	3.04	0.77
176	Control mechanisms (e.g., hormones, photoperiods, tropisms)	2.32	1.03	2.69	0.79
177	Asexual reproduction	2.97	0.87	2.92	0.74
178	Sexual reproduction (flowers, fruits, seeds, dispersal, germination)	3.21	0.77	3.12	0.59
Animals					
179	Digestion and nutrition	3.31	0.74	3.19	0.69
180	Circulation	3.30	0.74	3.19	0.69
181	Respiration	3.29	0.73	3.19	0.69
182	Excretion	3.23	0.78	3.19	0.69
183	Nervous system	3.23	0.79	3.19	0.69
184	Musculoskeletal system	3.11	0.82	2.77	0.82
185	Immune and lymphatic systems	2.93	0.87	2.88	0.91
186	Endocrine system	2.92	0.86	2.88	0.91
187	Reproduction and development	3.41	0.70	3.04	0.77
188	Homeostasis	2.91	0.82	2.92	0.93
189	Responses to stimuli (taxes, instincts, conditioned reflexes, learned behaviors)	2.86	0.83	2.52	1.12
Ecology					
190	Population dynamics (intraspecific interaction)	2.64	0.97	2.73	0.83
191	Life-history patterns (e.g., r and k strategists)	2.20	1.05	2.19	0.94
192	Interspecific relationships	2.88	0.85	2.50	0.99
193	Community structure and niche	2.91	0.94	2.58	0.95
194	Social behavior (e.g., dominance, hierarchy, altruism)	2.70	0.92	2.27	0.83
195	Species diversity in communities	2.75	0.93	2.42	1.17
196	Succession	2.75	0.92	2.35	1.09
197	Aquatic and terrestrial ecosystems	2.94	0.84	2.65	0.89
198	Food webs and energy flow through ecosystems	3.24	0.73	2.92	1.09
199	Cycling of materials (e.g., nitrogen, water, carbon)	3.11	0.82	2.96	1.00
200	Biomes	2.99	0.89	2.28	1.06

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
F. EARTH AND SPACE SCIENCE					
Physical Geology					
203	Physical and chemical properties of minerals	2.96	0.91	2.68	0.72
204	General types of minerals (e.g., silicates, carbonates)	2.65	0.97	2.54	0.88
205	Types of rocks and the processes that form them	3.11	0.92	3.04	0.88
206	Folding and faulting	2.96	0.86	2.68	0.86
207	Earthquakes	3.11	0.81	2.93	0.81
208	Volcanoes	3.10	0.81	2.82	0.77
209	Rock magnetism	2.26	0.97	2.35	0.80
210	Isostasy	2.01	1.06	1.92	1.00
211	Evidence from seismic studies	2.38	1.08	2.23	0.91
212	Crust, mantle, and core	3.15	0.87	2.69	0.68
213	Lithosphere and asthenosphere	2.58	1.10	2.42	1.14
214	Convection in the mantle	2.64	0.96	2.31	0.97
215	Heat sources within the Earth	2.76	0.92	2.31	0.84
216	Hot spots	2.58	0.97	2.27	0.96
217	Plate tectonic theory	3.22	0.89	2.88	0.95
218	Physical and chemical weathering	3.13	0.90	2.85	0.78
219	Mass wasting (e.g., creep, slump)	2.33	1.04	2.00	1.08
220	Hydrologic cycle	2.97	0.95	2.69	1.01
221	Artesian and nonartesian wells	2.23	1.03	2.31	0.79
222	Process/structures of erosional/depositional features shaped by running water	2.95	0.88	3.12	0.73
Historical Geology					
223	Principle of uniformitarianism	2.27	1.14	2.31	1.12
224	Relative and absolute time (including dating techniques)	2.44	1.05	2.65	1.02
225	Geologic time scale	2.70	1.01	2.81	0.90
226	Principles of stratigraphy (e.g., cross relations, superposition)	2.14	1.08	2.12	1.18
227	Formation of atmosphere and hydrosphere	2.48	1.07	2.62	0.94
228	Types of fossils and evidence provided by fossils	2.71	0.90	2.88	0.86
229	Mass extinctions	2.52	1.01	2.65	0.98

		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
F. EARTH AND SPACE SCIENCE (cont.)					
Oceanography					
230	Wind-generated waves (e.g., formation, motion)	2.52	0.87	2.63	0.88
231	Tides	2.84	0.85	2.78	0.75
232	Ocean currents (global and local; surface and deep)	2.67	0.89	2.70	0.78
233	Shore processes (e.g., formation of dunes, beach profiles, wave effects)	2.57	0.88	2.37	0.79
234	Geographic location of oceans and seas	2.96	0.92	2.96	0.90
235	Physical and chemical properties of the ocean	2.64	0.91	2.67	0.73
236	Topography of the ocean floor	2.70	0.89	2.22	0.85
237	Effects of plate tectonics on the geology/biology/topography of the ocean floor	2.95	0.93	2.63	1.18
238	Nutrient cycles of the ocean	2.58	0.92	2.63	0.88
Meteorology					
239	Physical and chemical properties of atmospheric layers	2.63	0.92	2.41	1.08
240	Seasonal and latitudinal variation of solar radiation	2.59	1.06	2.59	0.97
241	Heat budget of the atmosphere and the natural greenhouse effect	2.98	0.85	3.07	0.72
242	Causes of winds	2.94	0.87	3.00	0.67
243	Global wind belts	2.61	0.94	2.79	0.69
244	Variations in circulation (e.g., sea and land breezes, monsoons, jet stream)	2.67	0.88	2.68	0.90
245	Relative and absolute humidity (e.g., dew, frost point)	2.83	0.88	2.89	0.74
246	Cloud types and formation	2.93	0.94	2.68	0.72
247	Precipitation types and formation	3.03	0.90	2.75	0.65
248	Air masses (e.g., temperature, moisture content, source areas)	2.90	0.84	2.57	0.74
249	High and low pressure systems (including storms)	3.04	0.90	2.89	0.64
250	Frontal systems (e.g., cold, warm, stationary, occluded) and associated weather	2.99	0.86	2.86	0.76
251	Weather maps and station models	2.86	0.84	2.64	0.87
252	Weather forecasting	2.79	0.96	2.68	0.86
253	Regional and local natural factors affecting climate (e.g., topography, latitude)	2.84	0.87	2.57	0.63
254	Desertification, enhanced greenhouse effect, volcanic ash effects on climate	2.82	0.95	2.78	1.01
Astronomy					
255	Theories of and evidence for the origin of the universe	2.89	0.91	3.00	0.94
256	Structure of the universe (e.g., galaxies, novas, black holes, quasars, stars)	2.93	0.88	2.93	0.94
257	Large units of distance (e.g., astronomical unit, light-year, parsec)	2.68	0.98	2.71	1.01

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		Teachers		Teacher Educators	
		Mean	SD	Mean	SD
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY					
F. EARTH AND SPACE SCIENCE (cont.)					
258	Origin and life cycle of stars	2.66	0.97	2.68	0.90
259	Origin of the solar system	2.86	1.03	2.93	0.90
260	Major features of the Sun (including its energy source)	3.01	0.85	3.00	0.67
261	Structure of the solar system (e.g., planets, moons, asteroids, comets)	3.22	0.88	3.21	0.69
262	Phases of the Moon	3.01	0.97	2.86	0.93
263	Lunar and solar eclipses	3.08	0.87	2.89	0.88
264	Causes of seasons	3.28	0.84	3.29	0.71
265	Factors determining the length of a planetary year and day	2.79	1.08	2.86	0.89
266	Time zones on the Earth	2.71	1.05	2.75	0.84
267	Space exploration	3.07	0.89	2.68	0.98
268	Exploration of Earth from space	2.85	1.01	2.57	0.88
G. SCIENCE, TECHNOLOGY, AND SOCIETY					
271	Issues associated with energy production and use	3.25	0.82	3.30	0.79
272	Issues associated with production and use of consumer products	2.96	0.87	3.03	0.76
273	Prob. caused by the biological magnification of toxic materials in food chains	3.26	0.79	3.10	0.80
274	Conservation of nonrenewable resources (e.g., soil, metals, and fossil fuels)	3.50	0.64	3.23	0.73
275	Rel. of geog. distribution of natural resources/population patterns/global politics	2.95	0.94	2.83	1.02
276	Issues associated with biotechnology	2.89	0.92	2.77	0.97
277	Biological and chemical control of agricultural pests	2.85	0.98	2.53	0.97
278	Effect of agricultural practice on the environment	2.93	0.93	2.83	0.99
279	Use of science and technology to predict and prepare for natural disasters	2.93	0.91	2.43	0.73
280	Use of technology in everyday devices	3.11	0.86	2.83	0.83
281	Issues associated with health and wellness	3.15	0.87	3.00	0.87
282	Issues associated with technology transfer	2.71	0.90	2.47	1.04

Appendix F

Statements Rated Less Than 2.50 by Teachers and Teacher Educators

		Teachers	Teacher Educators
		Mean	Mean
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY			
Methodology and Philosophy			
6	History of science, including contributions of various cultures	2.34	2.52
Mathematics, Measurement, and Data Manipulation			
10	Unit/dimensional analysis	2.49	2.84
11	Experimental errors (e.g., sources, precision, accuracy)	2.38	2.67
12	Measures of central tendency and dispersion(e.g., mean, median, S.D., range)	1.93	2.39
13	Mathematical relationships and patterns in numerical data	1.89	2.67
14	Simple digital (binary) logic	1.88	2.15
B. BASIC PRINCIPLES OF SCIENCE			
Heat and Thermodynamics			
37	Second law of thermodynamics	2.47	2.66
Atomic and Nuclear Structure			
38	Historical development of atomic models	2.34	2.36
41	Nuclear forces and binding energy	2.47	2.52
44	Chemical properties of radiation (e.g., alpha, beta, gamma decay)	2.27	2.48
45	Artificial and natural radiation	2.26	2.33
46	Half-life of radioactive isotopes	2.16	2.33
47	Nuclear reactions	2.58	2.27
C. PHYSICS			
Mechanics			
52	Rel. among position/velocity/centripetal acceleration for uniform circular motion	2.41	2.90
53	Relationship between position and time for periodic motion	2.25	2.57
61	Pascal's principle (hydrostatics)	2.07	2.53
62	Archimedes' principle (buoyancy)	2.43	2.67
63	Bernoulli's principle	2.40	2.43
64	Relativistic effects on length, mass, and time	2.36	2.13
Electricity and Magnetism			
68	Potential difference	2.44	2.83
70	Capacitance	2.01	2.48
71	Inductance	2.05	2.34
73	Transformers	2.45	2.69

		Teachers	Teacher Educators
		Mean	Mean
C. PHYSICS (cont.)			
76	Large scale generations and transmission of energy and power	2.44	2.24
77	Semiconductor devices (e.g., diodes, transistors)	2.23	2.38
Waves			
86	Interference	2.34	2.28
87	Dispersion	2.21	2.03
88	Standing waves and resonance	2.20	2.41
95	Polarization	2.39	2.41
D. CHEMISTRY			
Periodicity			
100	Trends in melting and boiling temperatures	2.50	2.37
101	Trends in atomic radii, ionization energy, electron affinity, and electronegativity	2.15	2.10
The Mole, Chemical Bonding and Molecular Geometry			
102	Mole concept and conversion among moles, molecules, grams	2.09	2.77
105	Classes of organic compounds (i.e., alkanes, alkenes, alcohols)	2.19	2.67
106	Percent composition of elements in a compound	2.34	2.73
107	Law of constant composition and law of multiple proportions	2.09	2.67
109	Electron dot formulas and structural formulas	2.46	2.57
110	Types of bonding related to electronegativity differences	1.99	2.17
111	Valence shell electron pair repulsion model (VSEPR)	1.83	1.97
112	Chem./physical properties of compounds related to type of bonding/geometry	2.04	2.20
The Kinetic Theory and States of Matter			
115	Assumptions of the kinetic molecular theory	2.41	2.47
117	Real versus ideal gases	1.86	2.10
118	Phase changes for a pure substance	2.27	2.43
119	Relationships among evaporation rate/boiling temperature/vapor pressure	2.38	2.43
120	Characteristics of crystals	2.24	2.23
Chemical Reactions			
123	Amounts of reactants and/or products using a balanced chemical equation	2.49	2.60
124	Endothermic and exothermic reactions	2.41	2.53
125	Collision theory and reaction rates	1.91	2.00
126	Activation energy and the effects of a catalyst	2.09	2.39

		Teachers	Teacher Educators
		Mean	Mean
D. CHEMISTRY (cont.)			
127	Rate-influencing factors in chemical reactions	2.35	2.58
128	Chemical equilibrium	2.26	2.52
129	Le Châtelier's principle	1.71	2.10
130	Factors that disturb equilibrium (e.g., temperature, pressure, concentration)	2.11	2.35
131	Oxidation and reduction reactions	2.28	2.52
132	Electrochemical cells and electrode reactions	2.02	2.32
133	Practical applications of electrochemistry	2.16	2.63
Solutions and Solubility			
137	Dissolving process and the factors that effect the rate of dissolving	2.55	2.45
139	Conductivity of solutions and the ionization process	2.37	2.42
140	Colligative properties of solutions	1.94	2.10
144	Buffer solutions	2.46	2.68
E. BIOLOGY			
The Cell			
147	Prokaryotic and eukaryotic cells	2.45	2.92
153	Interrelationships of metabolic pathways	2.19	2.73
154	Principles of enzymatic activity	2.16	2.80
Genetics			
159	Basic mechanisms of protein synthesis	2.36	2.85
161	Genetic engineering	2.48	2.50
Evolution			
169	Isolating mechanisms and speciation	2.26	2.46
Plants			
176	Control mechanisms (e.g., hormones, photoperiods, tropisms)	2.32	2.69
Ecology			
191	Life-history patterns (e.g., r and k strategists)	2.20	2.19
194	Social behavior (e.g., dominance, hierarchy, altruism)	2.70	2.27
195	Species diversity in communities	2.75	2.42
196	Succession	2.75	2.35
200	Biomes	2.99	2.28

		Teachers	Teacher Educators
		Mean	Mean
F. EARTH AND SPACE SCIENCE			
Physical Geology			
209	Rock magnetism	2.26	2.35
210	Isostasy	2.01	1.92
211	Evidence from seismic studies	2.38	2.23
213	Lithosphere and asthenosphere	2.58	2.42
214	Convection in the mantle	2.64	2.31
215	Heat sources within the Earth	2.76	2.31
216	Hot spots	2.58	2.27
219	Mass wasting (e.g., creep, slump)	2.33	2.00
221	Artesian and nonartesian wells	2.23	2.31
Historical Geology			
223	Principle of uniformitarianism	2.27	2.31
224	Relative and absolute time (including dating techniques)	2.44	2.65
226	Principles of stratigraphy (e.g., cross relations, superposition)	2.14	2.12
227	Formation of atmosphere and hydrosphere	2.48	2.62
Oceanography			
233	Shore processes (e.g., formation of dunes, beach profiles, wave effects)	2.57	2.37
236	Topography of the ocean floor	2.70	2.22
Meteorology			
239	Physical and chemical properties of atmospheric layers	2.63	2.41
G. SCIENCE, TECHNOLOGY, AND SOCIETY			
279	Use of science and technology to predict and prepare for natural disasters	2.93	2.43
282	Issues associated with technology transfer	2.71	2.47

Appendix G

Percent of Responses by
Level of Understanding Category

		Level of Understanding				
		% Responding				
		0	1	2	3	4
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY						
Methodology and Philosophy						
1	Scientific methods (e.g., formulation of problem, hypotheses, etc.)	.00	1.12	7.87	34.27	56.74
2	Facts, models, theories, and laws	.00	6.86	1.14	45.71	26.29
3	Design of experiments (e.g., controls, independent/dependent variables)	1.13	1.13	9.04	46.33	42.37
4	Observations, interpretations, and inferences	.00	1.72	13.22	45.98	39.08
5	Qualitative and quantitative observations	.57	3.98	19.32	49.43	26.70
6	History of science, including contributions of various cultures	4.52	13.56	50.28	22.60	9.04
Mathematics, Measurement, and Data Manipulation						
7	The metric systems	.00	1.69	7.34	35.03	55.93
8	Scientific notation	1.14	2.84	29.55	40.91	25.57
9	Significant figures in measurement and calculations	1.71	6.86	32.57	41.14	17.71
10	Unit/dimensional analysis	4.07	9.30	31.98	36.05	18.60
11	Experimental errors (e.g., sources, precision, accuracy)	2.86	13.71	36.57	34.86	12.00
12	Measures of central tendency and dispersion(e.g., mean, median, S.D., range)	8.67	16.18	38 73	27.17	9.25
13	Mathematical relationships and patterns in numerical data	9.14	18.86	38.29	20.57	13.14
14	Simple digital (binary) logic	11.11	25.15	32.16	20.47	11.11
15	Presentation and interpretation of data in tables, graphs, charts, and maps	.58	.58	6.94	36.99	54.91
Laborato y, Field Activities, and Safety						
16	Laboratory and field equipment (e.g., balances, scales, ammeters, etc.)	.00	1.16	7.51	50.29	41.04
17	Preparation of specimens and materials (e.g., biological specimens, mixtures)	1.74	4.07	19.19	50.58	24.42
18	Safety procedures	.58	1.16	3.49	36.05	58.72
19	Laboratory and field hazards	.58	.58	9.94	38.60	50.29
20	Storage and disposal of materials	.58	2.31	9.25	41.04	46.82
B. BASIC PRINCIPLES OF SCIENCE						
23	Physical and chemical properties	4.05	4.05	15.61	46.82	33.53
24	Particulate nature of matter	2.89	2.89	14.45	39.31	43.35
25	Elements, names, symbols, occurrence, and relative abundance	.00	4.68	30.41	39.77	25.15
26	Physical and chemical changes	.00	1.74	20.93	44.19	33.14
27	Conservation of mass/energy	.00	1.74	25.00	37.79	35.47

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		Level of Understanding				
		% Responding				
		0	1	2	3	4
B.BASIC PRINCIPLES OF SCIENCE (cont.)						
28	Forms of energy	.00	2.91	20.93	38.95	37.21
29	Energy transformations	.00	4.65	22.67	44.77	27.91
Heat and Thermodynamics						
30	Heat versus temperature	.00	5.85	33.92	38.60	21.64
31	Temperature scales and measurement	.00	4.05	20.81	46.82	28.32
32	Conduction, convection, and radiation	.58	5.23	30.81	37.21	26.16
33	Heat capacity/thermal exchange/heat of fusion and vaporization	1.75	12.87	38.60	33.33	13.45
34	Phase changes	.00	4.07	21.51	44.19	30.23
35	Expansion and contraction	.00	5.23	29.07	45.93	19.77
36	First law of thermodynamics	2.35	10.00	35.88	32.35	19.41
37	Second law of thermodynamics	2.35	12.35	34.12	34.12	17.06
Atomic and Nuclear Structure						
38	Historical development of atomic models	3.51	19.88	38.01	23.39	15.20
39	Structure of the atom	.00	1.69	19.10	33.71	45.51
40	Atomic mass, atomic number, mass number, and isotopes	1.12	3.37	24.16	35.96	35.39
41	Nuclear forces and binding energy	2.82	10.17	48.59	30.51	7.91
42	Characteristics of an electron in an atom	1.14	7.39	35.80	30.68	25.00
43	Chemical properties related to electron configuration	2.84	10.23	34.09	31.82	21.02
44	Chemical properties of radiation (e.g., alpha, beta, gamma decay)	3.37	16.29	41.57	29.78	8.99
45	Artificial and natural radiation	3.39	17.51	45.76	25.42	7.91
46	Half-life of radioactive isotopes	4.49	17.42	39.89	30.90	7.30
47	Nuclear reactions	3.39	16.95	37.29	29.38	12.99
C. PHYSICS						
Mechanics						
50	Relationships among position/velocity/acceleration for motion in a straight line	.58	9.94	24.56	39.18	25.73
51	Rel. among position/velocity/constant acceleration for projectile motion	1.75	10.53	33.33	35.67	18.71
52	Rel. among position/velocity/centripetal acceleration for uniform circular motion	1.75	12.28	37.43	32.75	15.79
53	Relationship between position and time for periodic motion	3.47	15.03	38.73	32.37	10.40
54	Newton's law of motion	.00	4.02	21.26	36.78	37.93

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C.PHYSICS (cont.)						
55	Relationships among work, energy, and power	.00	4.02	17.24	45.98	32.76
56	Simple machines, torque	.58	5.20	25.43	45.66	23.12
57	Friction	.00	4.02	29.31	43.68	22.99
58	Conservation of momentum	1.16	6.94	30.06	46.24	15.61
59	Conservation of energy	.00	4.62	21.97	42.20	31.21
60	Newton's law of gravity	.00	4.07	20.93	45.35	29.65
61	Pascal's principle (hydrostatics)	5.26	16.96	42.11	26.90	8.77
62	Archimedes' principle (buoyancy)	3.49	11.63	33.72	37.21	13.95
63	Bernouilli's principle	2.91	15.12	38.37	33.14	10.47
64	Relativistic effects on length, mass, and time	4.62	15.61	35.84	31.79	12.14
Electricity and Magnetism						
65	Repulsion and attraction of electric charges	.00	5.81	16.28	44.19	33.72
66	Series and parallel circuits	.00	6.36	16.18	49.71	27.75
67	Resistance	1.17	8.19	24.56	48.54	17.54
68	Potential difference	2.92	12.28	32.16	38.01	14.62
69	Current	1.76	8.82	22.35	42.94	24.12
70	Capacitance	6.59	13.77	44.31	29.34	5.99
71	Inductance	5.33	15.98	45.56	26.04	7.10
72	Direct current (DC) and alternating current (AC)	.59	7.65	25.88	40.00	25.88
73	Transformers	1.76	13.53	32.94	39.41	12.35
74	Motors	1.78	13.02	31.95	40.24	13.02
75	Sources of EMF (e.g., batteries, solar cells, generators)	1.18	7.65	32.94	40.59	17.65
76	Large scale generations and transmission of energy and power	3.55	15.98	35.50	34.32	10.65
77	Semiconductor devices (e.g., diodes, transistors)	4.12	18.24	33.53	33.53	10.59
78	Magnets	.00	4.09	24.56	46.78	24.56
79	Magnetic fields	.58	7.60	25.15	46.78	19.88
80	Magnetic forces	1.17	8.77	25.73	45.61	18.71

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D. CHEMISTRY (cont.)						
108	Ionic, covalent, and metallic bonds	2.96	12.43	21.89	40.83	21.89
109	Electron dot formulas and structural formulas	4.14	16.57	28.99	33.73	16.57
110	Types of bonding related to electronegativity differences	10.65	19.53	31.95	30.77	7.10
111	Valence shell electron pair repulsion model (VSEPR)	14.79	23.08	28.99	25.44	7.69
112	Chem./physical properties of compounds related to type of bonding/geometry	9.47	22.49	31.36	27.81	8.88
The Kinetic Theory and States of Matter						
113	Special properties of water (e.g., density of solid versus liquid)	11.76	15.29	22.94	38.24	21.76
114	Rel. among phases of matter, forces between particles and particle energy	13.55	13.02	31.36	31.36	20.71
115	Assumptions of the kinetic molecular theory	14.14	15.98	33.14	33.14	13.61
116	Relationships among volume/pressure/temperature/quantity for ideal gases	22.99	11.98	27.54	37.13	20.36
117	Real versus ideal gases	19.64	25.30	33.73	23.49	7.83
118	Phase changes for a pure substance	14.73	16.57	37.87	27.22	13.61
119	Relationships among evaporation rate/boiling temperature/vapor pressure	11.78	16.57	37.28	29.59	14.79
120	Characteristics of crystals	12.35	15.88	48.24	25.29	8.24
Chemical Reactions						
121	Equation balancing from written description of chemical reaction	1.78	10.06	21.89	39.05	27.22
122	General types of chemical reactions	2.35	11.18	26.47	36.47	23.53
123	Amounts of reactants and/or products using a balanced chemical equation	3.53	9.41	31.76	35.29	20.00
124	Endothermic and exothermic reactions	4.73	11.24	31.95	40.24	11.83
125	Collision theory and reaction rates	8.88	19.53	39.05	27.81	4.73
126	Activation energy and the effects of a catalyst	7.65	15.29	42.35	25.29	9.41
127	Rate-influencing factors in chemical reactions	4.73	13.02	37.87	31.36	13.02
128	Chemical equilibrium	5.99	12.57	35.93	31.14	14.37
129	Le Châtelier's principle	12.12	25.45	35.15	20.00	7.27
130	Factors that disturb equilibrium (e.g., temperature, pressure, concentration)	8.82	17.06	34.12	27.65	12.35
131	Oxidation and reduction reactions	4.71	18.24	31.18	30.00	15.88
132	Electrochemical cells and electrode reactions	5.92	18.93	42.01	24.26	8.88
133	Practical applications of electrochemistry	5.88	18.24	32.94	32.94	10.00

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C.PHYSICS (cont.)						
Waves						
81	Wave characteristics (speed, amplitude, wavelength, frequency)	.00	5.88	24.71	37.06	32.35
82	Transverse and longitudinal waves	.00	8.93	32.74	35.71	22.62
83	Reflection	.58	7.02	26.90	43.27	22.22
84	Refraction	.58	7.60	26.32	43.86	21.64
85	Diffraction	1.18	10.59	32.94	38.82	16.47
86	Interference	2.38	20.24	36.31	30.95	10.12
87	Dispersion	4.14	22.49	39.64	24.85	8.88
88	Standing waves and resonance	2.96	18.34	43.20	25.44	10.06
89	Doppler effect	.60	11.90	34.52	34.52	18.45
90	Characteristics of sound waves (e.g., pitch, loudness, speed, timbre, beats)	1.78	8.88	29.59	33.73	26.04
91	The electromagnetic spectrum (gamma rays to radio waves)	1.78	5.92	30.18	36.09	26.04
92	Color	.00	7.06	27.65	39.41	25.88
93	Laser light	.59	11.76	40.59	31.76	15.29
94	Optics (e.g., mirrors, lenses, prisms, fiber optics)	.00	7.06	29.41	42.35	21.18
95	Polarization	.59	15.38	44.38	30.18	9.47
D. CHEMISTRY						
Periodicity						
98	The periodic table	.58	1.74	16.28	39.53	41.86
99	The position of solids, liquids, etc. on the periodic table	1.16	5.81	28.49	37.79	26.74
100	Trends in melting and boiling temperatures	2.35	15.88	34.12	34.71	12.94
101	Trends in atomic radii, ionization energy, electron affinity, and electronegativity	5.88	18.24	37.06	30.59	8.24
The Mole, Chemical Bonding and Molecular Geometry						
102	Mole concept and conversion among moles, molecules, grams	7.74	16.67	28.57	33.33	13.69
103	Information conveyed by a chemical formula	.60	7.19	15.57	41.92	34.73
104	Simple inorganic nomenclature	2.98	14.88	25.00	33.93	23.21
105	Classes of organic compounds (i.e., alkanes, alkenes, alcohols)	5.29	17.06	38.24	25.29	14.12
106	Percent composition of elements in a compound	4.19	14.37	30.54	34.13	16.77
107	Law of constant composition and law of multiple proportions	4.82	21.08	30.72	31.33	12.05

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D. CHEMISTRY (cont.)						
Solutions and Solubility						
134	Types of solutions	1.16	11.05	31.40	33.14	23.26
135	Selective nature of solvents (e.g., like dissolves like)	1.74	13.37	36.63	33.72	14.53
136	Effects of temperature and pressure on solubility	.00	9.94	38.01	35.67	16.37
137	Dissolving process and the factors that effect the rate of dissolving	2.33	10.47	38.37	33.14	15.70
138	Concentration of solutions	.58	9.30	29.07	38.37	22.67
139	Conductivity of solutions and the ionization process	4.07	16.86	33.72	35.47	9.88
140	Colligative properties of solutions	8.93	21.43	36.90	26.79	5.95
141	Acids, bases, and salts	.00	4.05	20.23	43.35	32.37
142	pH	.00	4.05	21.97	45.09	28.90
143	Strong versus weak acids and bases	1.17	7.02	32.16	37.43	22.22
144	Buffer solutions	2.34	13.45	35.67	32.16	16.37
E. BIOLOGY						
The Cell						
147	Prokaryotic and eukaryotic cells	5.52	14.11	31.29	29.45	19.63
148	Structure and functions of cellular organelles	2.45	7.98	25.15	38.04	26.38
149	Plant and animal cells	.00	1.20	17.47	39.16	42.17
150	Structure and function of membranes (e.g., active transport, plasmolysis)	1.21	1.82	26.67	41.21	29.09
151	Chemical reactions in respiration	1.82	8.48	36.36	31.52	21.82
152	Chemical reactions in photosynthesis	.60	6.02	33.73	33.13	26.51
153	Interrelationships of metabolic pathways	6.06	12.73	40.61	27.88	12.73
154	Principles of enzymatic activity	4.94	16.05	35.80	30.86	12.35
155	Cell cycle	3.09	10.49	27.16	36.42	22.84
156	Stages and purposes of mitosis and cytokinesis	1.23	4.94	27.16	41.36	25.31
157	Stages and purposes of meiosis	1.23	6.75	24.54	41.72	25.77
Genetics						
158	Structure and replication of DNA	.62	6.79	31.48	36.42	24.69
159	Basic mechanisms of protein synthesis	3.66	12.20	37.20	26.83	20.12
160	Causes and results of mutations	2.45	12.27	30.67	33.74	20.86

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E. BIOLOGY (cont.)						
161	Genetic engineering	4.27	12.80	34.15	33.54	15.24
162	Mendel's Laws and monohybrid and dihybrid crosses	2.45	6.13	19.63	43.56	28.22
163	Non-Mendelian inheritance (e.g., multiple alleles, multiple genes)	3.68	12.88	28.22	38.65	16.56
164	Interaction between heredity and environment	1.23	5.52	20.86	41.72	30.67
165	Human genetic disorders	1.88	8.13	33.13	33.13	23.75
Evolution						
166	Historical developments relating to the origin of life	4.32	12.35	33.95	28.40	20.99
167	Evidence for and factors affecting evolution	4.29	12.88	25.77	30.06	26.99
168	Theories and patterns of evolution	4.32	14.81	23.46	32.10	25.31
169	Isolating mechanisms and speciation	7.98	17.18	33.13	30.06	11.66
Diversity of Life						
170	General characteristics of life	.61	1.23	13.50	37.42	47.24
171	Classification schemes (Five Kingdoms and nomenclature)	.00	3.03	24.24	40.00	32.73
172	Characteristics of viruses, monerans, protists, fungi, plants and animals	.00	6.67	20.61	42.42	30.30
Plants						
173	Nonvascular and vascular plants	1.21	3.64	23.64	47.27	24.24
174	Structure and functions of roots, stems, and leaves	.00	1.83	20.12	46.34	31.71
175	Transport systems, nutrient uptake	.61	5.52	26.99	44.17	22.70
176	Control mechanisms (e.g., hormones, photoperiods, tropisms)	3.07	6.75	42.94	34.36	12.88
177	Asexual reproduction	1.21	3.03	28.48	45.45	21.82
178	Sexual reproduction (flowers, fruits, seeds, dispersal, germination)	.00	2.44	23.17	42.07	32.32
Animals						
179	Digestion and nutrition	.61	.61	20.61	41.82	36.36
180	Circulation	.61	.61	20.86	42.94	34.97
181	Respiration	.61	.61	20.12	43.90	34.76
182	Excretion	.61	1.22	20.12	45.12	32.93
183	Nervous system	.61	1.22	21.34	43.29	33.54
184	Musculoskeletal system	.00	4.24	24.85	44.24	26.67
185	Immune and lymphatic systems	.00	4.82	28.92	40.36	25.90

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E. BIOLOGY (cont.)						
186	Endocrine system	.00	4.82	30.72	41.57	22.89
187	Reproduction and development	.00	2.41	18.67	40.36	38.55
188	Homeostasis	.61	6.06	30.30	41.21	21.82
189	Responses to stimuli (taxes, instincts, conditioned reflexes, learned behaviors)	1.22	6.71	29.27	37.80	25.00
Ecology						
190	Population dynamics (intraspecific interaction)	1.82	11.52	27.27	37.58	21.82
191	Life-history patterns (e.g., r and k strategists)	9.04	13.86	33.73	32.53	10.84
192	Interspecific relationships	1.81	10.24	23.49	40.96	23.49
193	Community structure and niche	1.20	9.64	21.69	39.76	27.71
194	Social behavior (e.g., dominance, hierarchy, altruism)	2.41	10.84	26.51	39.16	21.08
195	Species diversity in communities	2.41	10.24	26.51	37.35	23.49
196	Succession	1.81	11.45	26.51	37.95	22.29
197	Aquatic and terrestrial ecosystems	.00	7.83	24.10	38.55	29.52
198	Food webs and energy flow through ecosystems	.60	4.22	15.66	39.16	40.36
199	Cycling of materials (e.g., nitrogen, water, carbon)	.60	2.41	22.89	36.14	37.95
200	Biomes	.61	4.85	33.33	29.09	32.12
F. EARTH AND SPACE SCIENCE						
Physical Geology						
203	Physical and chemical properties of minerals	.61	6.06	29.09	38.79	25.45
204	General types of minerals (e.g., silicates, carbonates)	.61	10.37	38.41	32.93	17.68
205	Types of rocks and the processes that form them	.61	4.85	23.03	38.79	32.73
206	Folding and faulting	1.21	5.45	26.06	39.39	27.88
207	Earthquakes	.61	3.64	27.88	35.15	32.73
208	Volcanoes	.61	4.24	27.88	37.58	29.70
209	Rock magnetism	2.44	19.51	39.63	26.83	11.59
210	Isostasy	6.88	25.00	34.38	23.75	10.00
211	Evidence from seismic studies	3.68	18.40	33.13	25.15	19.63
212	Crust, mantle, and core	1.23	7.98	28.22	33.74	28.83
213	Lithosphere and asthenosphere	5.56	10.49	42.59	23.46	17.90

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F. EARTH AND SPACE SCIENCE (cont.)						
214	Convection in the mantle	3.68	14.72	34.97	29.45	17.18
215	Heat sources within the Earth	2.44	8.54	40.85	28.66	19.51
216	Hot spots	1.83	13.41	44.51	23.78	16.46
217	Plate tectonic theory	1.22	4.88	23.17	35.98	34.76
218	Physical and chemical weathering	1.22	7.93	22.56	37.20	31.10
219	Mass wasting (e.g., creep, slump)	6.13	18.40	36.81	25.77	12.88
220	Hydrologic cycle	1.84	8.59	22.70	36.81	30.06
221	Artesian and nonartesian wells	3.66	16.46	40.24	29.88	9.76
222	Process/structures of erosional/depositional features shaped by running water	.61	6.75	23.93	42.94	25.77
Historical Geology						
223	Principle of uniformitarianism	7.36	17.79	36.81	20.86	17.18
224	Relative and absolute time (including dating techniques)	4.88	12.80	39.63	26.22	16.46
225	Geologic time scale	3.05	11.59	32.93	31.10	21.34
226	Principles of stratigraphy (e.g., cross relations, superposition)	10.43	15.34	38.04	25.15	11.04
227	Formation of atmosphere and hydrosphere	1.83	4.27	37.20	37.20	19.51
228	Types of fossils and evidence provided by fossils	1.83	4.27	37.20	37.20	19.51
229	Mass extinctions	4.91	12.27	35.58	29.45	17.79
Oceanography						
230	Wind-generated waves (e.g., formation, motion)	.61	14.63	40.24	29.88	14.63
231	Tides	.61	7.27	34.55	37.58	20.00
232	Ocean currents (global and local; surface and deep)	.00	9.09	36.36	37.58	16.97
233	Shore processes (e.g., formation of dunes, beach profiles, wave effects)	.00	12.12	38.18	33.33	16.36
234	Geographic location of oceans and seas	.61	6.67	32.73	37.58	22.42
235	Physical and chemical properties of the ocean	.61	10.43	40.49	32.52	15.95
236	Topography of the ocean floor	.61	9.20	43.56	30.06	16.56
237	Effects of plate tectonics on the geology, biology, and topography of the ocean floor	3.07	4.29	33.74	31.90	26.99
238	Nutrient cycles of the ocean	1.84	10.43	34.97	34.36	18.40

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F. EARTH AND SPACE SCIENCE (cont.)						
Meteorology						
239	Physical and chemical properties of atmospheric layers	1.21	14.55	31.52	35.76	16.97
240	Seasonal and latitudinal variation of solar radiation	2.41	11.45	36.75	28.31	21.08
241	Heat budget of the atmosphere and the natural greenhouse effect	.00	4.22	27.11	36.75	31.93
242	Causes of winds	.60	5.42	28.31	39.76	25.90
243	Global wind belts	1.82	10.91	37.58	33.33	16.36
244	Variations in circulation (e.g., sea and land breezes, monsoons, jet stream)	.60	9.04	36.14	38.55	15.66
245	Relative and absolute humidity (e.g., dew, frost point)	.60	8.43	29.52	40.96	20.48
246	Cloud types and formation	1.20	7.23	31.33	39.16	21.08
247	Precipitation types and formation	.60	6.02	28.31	39.76	25.30
248	Air masses (e.g., temperature, moisture content, source areas)	.00	8.54	31.10	40.24	20.12
249	High and low pressure systems (including storms)	1.22	3.66	28.66	37.80	28.66
250	Frontal systems (e.g., cold, warm, stationary, occluded) and associated weather	1.20	5.42	25.90	45.18	22.29
251	Weather maps and station models	1.20	6.02	29.52	39.16	24.10
252	Weather forecasting	1.82	8.48	27.88	40.00	21.82
253	Regional and local natural factors affecting climate (e.g., topography, latitude)	.00	8.43	33.73	33.73	24.10
254	Desertification, enhanced greenhouse effect, volcanic ash effects on climate	1.21	9.70	29.09	33.94	26.06
Astronomy						
255	Theories of and evidence for the origin of the universe	1.21	6.67	30.91	35.15	26.06
256	Structure of the universe (e.g., galaxies, novas, black holes, quasars, stars)	1.21	6.06	34.55	35.15	23.03
257	Large units of distance (e.g., astronomical unit, light-year, parsec)	1.20	12.65	31.93	36.75	17.47
258	Origin and life cycle of stars	2.42	9.09	40.00	31.52	16.97
259	Origin of the solar system	2.42	7.88	33.33	31.52	24.85
260	Major features of the Sun (including its energy source)	.61	3.64	34.55	41.82	19.39
261	Structure of the solar system (e.g., planets, moons, asteroids, comets)	.60	6.02	21.69	41.57	30.12
262	Phases of the Moon	1.81	7.23	25.30	37.35	28.31
263	Lunar and solar eclipses	.60	5.42	28.31	33.73	31.93
264	Causes of seasons	1.20	2.41	20.48	37.95	37.95
265	Factors determining the length of a planetary year and day	1.81	9.04	33.73	29.52	25.90

Level of Understanding: 0 = An understanding of the knowledge area is not needed; 1 = Define the terms used in the knowledge area; 2 = Comprehend the essential properties of the knowledge area; 3 = Apply/Utilize the knowledge area to address problems or questions; 4 = Analyze the knowledge area into component parts and explain the interrelationships among the parts.

		Level of Understanding				
		% Responding				
		0	1	2	3	4
F. EARTH AND SPACE SCIENCE (cont.)						
266	Time zones on the Earth	2.41	7.23	28.92	38.55	22.89
267	Space exploration	1.21	3.64	30.30	40.00	24.85
268	Exploration of Earth from space	2.44	7.32	32.93	33.54	23.78
G. SCIENCE, TECHNOLOGY, AND SOCIETY						
271	Issues associated with energy production and use	.60	3.59	17.96	46.11	31.74
272	Issues associated with production and use of consumer products	.00	6.67	23.64	43.64	26.06
273	Prob. caused by the biological magnification of toxic materials in food chains	.00	4.22	16.87	46.39	32.53
274	Conservation of nonrenewable resources (e.g., soil, metals, and fossil fuels)	.00	1.20	10.84	45.78	42.17
275	Rel. of geog. distribution of natural resources/population patterns/global politics	.00	10.84	19.88	46.39	22.89
276	Issues associated with biotechnology	.00	9.64	23.49	46.39	20.48
277	Biological and chemical control of agricultural pests	.60	11.45	22.29	42.77	22.89
278	Effect of agricultural practice on the environment	.61	6.06	23.64	44.24	25.45
279	Use of science and technology to predict and prepare for natural disasters	.61	9.70	23.03	47.27	19.39
280	Use of technology in everyday devices	1.20	3.01	22.89	48.19	24.70
281	Issues associated with health and wellness	1.20	3.01	18.07	51.20	26.51
282	Issues associated with technology transfer	1.21	11.52	27.88	44.85	14.55

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Appendix H

Mean Importance Ratings by Subgroups

		GEOGRAPHIC REGIONS			SEX		TEACHING EXPERIENCE	
		NE	C	S	F	M	≤10	>10
		N=46	N=48	N=55	N=81	N=95	N=46	N=69
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY								
Methodology and Philosophy								
1	Scientific methods (e.g., formulation of problem, hypotheses, etc.)	3.59	3.67	3.76	3.74	3.61	3.70	3.74
2	Facts, models, theories, and laws	2.98	3.06	3.38	3.19	3.14	3.00	3.26
3	Design of experiments (e.g., controls, independent/dependent variables)	3.50	3.33	3.38	3.56	3.24	3.46	3.42
4	Observations, interpretations, and inferences	3.52	3.48	3.35	3.35	3.48	3.27	3.49
5	Qualitative and quantitative observations	3.22	3.15	3.18	3.23	3.12	3.11	3.22
6	History of science, including contributions of various cultures	2.38	2.44	2.47	2.39	2.42	2.18	2.42
Mathematics, Measurement, and Data Manipulation								
7	The metric systems	3.52	3.56	3.67	3.62	3.56	3.57	3.55
8	Scientific notation	2.85	2.71	3.13	2.89	2.92	2.57	2.93
9	Significant figures in measurement and calculations	2.65	2.55	3.02	2.79	2.65	2.39	2.78
10	Unit/dimensional analysis	2.53	2.40	2.74	2.63	2.53	2.37	2.61
11	Experimental errors (e.g., sources, precision, accuracy)	2.48	2.23	2.67	2.56	2.40	2.24	2.49
12	Measures of central tendency and dispersion(e.g., mean, median, mode, S.D., range)	1.91	1.94	2.43	2.19	1.98	1.71	2.04
13	Mathematical relationships and patterns in numerical data	2.02	2.04	2.27	2.08	2.13	1.63	2.04
14	Simple digital (binary) logic	1.69	1.71	2.17	1.97	1.87	1.72	2.00
15	Presentation and interpretation of data in tables, graphs, charts, and maps	3.58	3.54	3.56	3.52	3.58	3.54	3.52

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		N=46	N=48	N=55	N=81	N=95	N=46	N=69
A. SCIENTIFIC METHODOLOGY/TECHNIQUES/HISTORY (cont.)								
Laboratory, Field Activities, and Safety								
16	Laboratory and field equipment (e.g., balances, scales, ammeters, etc.)	3.78	3.39	3.54	3.67	3.52	3.63	3.68
17	Preparation of specimens and materials (e.g., biological specimens, solutions, mixtures)	3.22	2.96	3.15	3.29	2.92	3.07	3.09
18	Safety procedures	3.91	3.80	3.87	3.90	3.84	3.96	3.88
19	Laboratory and field hazards	3.80	3.63	3.73	3.77	3.63	3.67	3.72
20	Storage and disposal of materials	3.60	3.52	3.72	3.73	3.48	3.59	3.65
21	Overall Importance of Scientific Methodology/Techniques/History	3.39	3.37	3.42	3.46	3.29	3.26	3.45
B. BASIC PRINCIPLES OF SCIENCE								
23	Physical and chemical properties	3.43	3.28	3.35	3.42	3.27	3.28	3.43
24	Particulate nature of matter	3.41	3.26	3.54	3.48	3.37	3.46	3.45
25	Elements, names, symbols, occurrence, and relative abundance	3.07	2.84	3.31	3.20	2.93	3.04	3.15
26	Physical and chemical changes	3.28	3.17	3.41	3.37	3.23	3.22	3.40
27	Conservation of mass/energy	3.18	3.00	3.41	3.27	3.18	3.00	3.31
28	Forms of energy	3.36	3.11	3.36	3.34	3.21	3.28	3.40
29	Energy transformations	3.20	2.89	3.17	3.09	3.04	2.83	3.18
Heat and Thermodynamics								
30	Heat versus temperature	2.86	2.72	2.94	2.87	2.76	2.59	2.89
31	Temperature scales and measurement	3.18	2.96	3.31	3.25	3.03	3.15	3.23
32	Conduction, convection, and radiation	3.02	2.78	3.17	3.09	2.86	2.93	3.05
33	Heat capacity/thermal exchange/heat of fusion and vaporization	2.41	2.41	2.76	2.60	2.48	2.24	2.74

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B. BASIC PRINCIPLES OF SCIENCE (cont.)								
34	Phase changes	3.00	3.04	3.09	3.24	2.91	3.24	3.06
35	Expansion and contraction	3.00	2.83	2.93	3.00	2.82	2.87	2.98
36	First law of thermodynamics	2.44	2.54	2.87	2.68	2.61	2.57	2.57
37	Second law of thermodynamics	2.33	2.43	2.78	2.58	2.51	2.46	2.46
Atomic and Nuclear Structure								
38	Historical development of atomic models	2.18	2.20	2.69	2.41	2.36	2.30	2.37
39	Structure of the atom	3.41	3.40	3.64	3.53	3.44	3.67	3.42
40	Atomic mass, atomic number, mass number, and isotopes	3.24	3.17	3.40	3.25	3.22	3.24	3.22
41	Nuclear forces and binding energy	2.46	2.27	2.69	2.64	2.33	2.48	2.47
42	Characteristics of an electron in an atom	2.70	2.73	3.11	3.02	2.71	2.89	2.86
43	Chemical properties related to electron configuration	2.59	2.40	2.89	2.60	2.66	2.48	2.61
44	Chemical properties of radiation (e.g., alpha, beta, gamma decay)	2.13	2.23	2.69	2.35	2.36	2.17	2.38
45	Artificial and natural radiation	2.15	2.17	2.56	2.30	2.35	2.04	2.41
46	Half-life of radioactive isotopes	1.98	2.21	2.47	2.26	2.21	2.00	2.26
47	Nuclear reactions	2.17	2.50	2.89	2.59	2.52	2.46	2.68
48	Overall importance of Basic Principles of Science	3.16	3.04	3.27	3.23	3.08	3.25	3.09
C. PHYSICS								
Mechanics								
50	Relationships among position, velocity, and acceleration for motion in a straight line	2.76	2.65	3.13	2.90	2.78	2.69	2.85
51	Relationships among position, velocity, and constant acceleration for projectile motion	2.53	2.50	2.79	2.62	2.59	2.38	2.59

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		N=46	N=48	N=55	N=81	N=95	N=46	N=69
C. PHYSICS (cont.)								
52	Rel. among position, velocity, and centripetal acceleration for uniform circular motion	2.47	2.24	2.74	2.57	2.42	2.29	2.47
53	Relationship between position and time for periodic motion	2.29	2.09	2.55	2.43	2.25	2.18	2.28
54	Newton's law of motion	3.22	3.02	3.46	3.30	3.23	3.30	3.19
55	Relationships among work, energy, and power	3.09	3.00	3.37	3.18	3.15	3.13	3.21
56	Simple machines, torque	2.98	2.78	3.26	3.14	2.85	2.89	3.03
57	Friction	3.00	2.78	3.35	3.18	2.92	3.07	3.07
58	Conservation of momentum	2.73	2.60	3.06	2.80	2.79	2.54	2.78
59	Conservation of energy	3.20	2.96	3.41	3.18	3.16	3.15	3.07
60	Newton's law of gravity	3.20	3.00	3.43	3.25	3.18	3.15	3.25
61	Pascal's principle (hydrostatics)	2.05	1.78	2.50	2.19	2.15	1.76	2.27
62	Archimedes' principle (buoyancy)	2.58	2.11	2.67	2.53	2.45	2.17	2.58
63	Bernoulli's principle	2.38	2.14	2.63	2.54	2.30	2.27	2.46
64	Relativistic effects on length, mass, and time	2.13	2.16	2.50	2.54	2.13	2.22	2.42
Electricity and Magnetism								
65	Repulsion and attraction of electric charges	3.20	3.18	3.37	3.32	3.22	3.26	3.22
66	Series and parallel circuits	3.07	2.78	3.28	3.18	2.92	3.04	3.12
67	Resistance	2.84	2.56	3.02	2.87	2.73	2.57	2.81
68	Potential difference	2.68	2.22	2.70	2.51	2.57	2.17	2.61
69	Current	3.07	2.67	3.02	2.92	2.90	2.72	3.00
70	Capacitance	2.07	1.78	2.42	2.17	2.07	1.76	2.17

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C. PHYSICS (cont.)								
71	Inductance	2.20	1.76	2.37	2.20	2.07	1.78	2.23
72	Direct current (DC) and alternating current (AC)	2.98	2.89	3.11	2.94	2.99	2.76	3.07
73	Transformers	2.57	2.24	2.74	2.57	2.47	2.28	2.55
74	Motors	2.59	2.47	2.74	2.70	2.53	2.48	2.61
75	Sources of EMF (e.g., batteries, solar cells, generators)	2.95	2.49	3.00	2.80	2.82	2.63	2.93
76	Large scale generations and transmission of energy and power	2.55	2.20	2.57	2.49	2.41	2.46	2.45
77	Semiconductor devices (e.g., diodes, transistors)	2.36	2.00	2.57	2.44	2.25	2.17	2.26
78	Magnets	3.25	2.82	3.31	3.28	2.97	3.00	3.15
79	Magnetic fields	3.05	2.69	3.07	3.14	2.74	2.83	2.97
80	Magnetic forces	2.93	2.67	3.04	3.03	2.73	2.80	2.93
Waves								
81	Wave characteristics (speed, amplitude, wavelength, frequency)	3.07	2.87	3.30	3.16	2.99	3.13	3.00
82	Transverse and longitudinal waves	2.75	2.60	3.15	2.92	2.78	2.89	2.83
83	Reflection	2.98	2.84	3.28	3.06	2.96	2.93	3.07
84	Refraction	2.95	2.87	3.26	3.06	2.93	2.91	3.07
85	Diffraction	2.61	2.64	2.96	2.85	2.64	2.63	2.79
86	Interference	2.16	2.18	2.57	2.44	2.24	2.26	2.39
87	Dispersion	2.00	2.02	2.43	2.34	2.03	2.07	2.29
88	Standing waves and resonance	2.16	2.11	2.43	2.29	2.21	2.07	2.27
89	Doppler effect	2.55	2.51	3.00	2.82	2.58	2.72	2.73

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		NE N=46	C N=48	S N=55	F N=81	M N=95	≤10 N=46	>10 N=69
C. PHYSICS (cont.)								
90	Characteristics of sound waves (e.g., pitch, loudness, speed, timbre, beats)	2.75	2.70	3.00	2.91	2.72	2.78	2.84
91	The electromagnetic spectrum (gamma rays to radio waves)	2.89	2.87	3.07	2.94	2.94	2.98	2.83
92	Color	3.05	2.82	3.17	3.05	2.96	3.04	3.01
93	Laser light	2.75	2.47	2.87	2.80	2.63	2.74	2.66
94	Optics (e.g., mirrors, lenses, prisms, fiber optics)	3.00	2.80	3.19	3.00	2.92	2.93	2.90
95	Polarization	2.32	2.27	2.57	2.49	2.40	2.33	2.42
96	Overall importance of Physics	3.00	2.90	3.19	3.01	3.01	2.89	2.98
D. CHEMISTRY								
Periodicity								
98	The periodic table	3.24	3.37	3.55	3.47	3.29	3.33	3.40
99	The position of solids, liquids, etc. on the periodic table	2.96	2.76	3.29	3.20	2.82	3.02	3.00
100	Trends in melting and boiling temperatures	2.41	2.44	2.62	2.54	2.47	2.42	2.54
101	Trends in atomic radii, ionization energy, electron affinity, and electronegativity	2.07	2.04	2.39	2.20	2.17	1.93	2.30
The Mole, Chemical Bonding and Molecular Geometry								
102	Mole concept and conversion among moles, molecules, grams	1.98	2.29	2.42	2.13	2.40	1.87	2.24
103	Information conveyed by a chemical formula	3.04	3.02	3.28	3.08	3.15	2.98	3.16
104	Simple inorganic nomenclature	2.58	2.51	2.98	2.62	2.80	2.51	2.71
105	Classes of organic compounds (i.e., alkanes, alkenes, alcohols)	2.16	2.09	2.70	2.39	2.25	1.98	2.28
106	Percent composition of elements in a compound	2.29	2.33	2.74	2.54	2.37	2.09	2.46
107	Law of constant composition and law of multiple proportions	2.11	2.09	2.52	2.17	2.34	1.89	2.19

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D. CHEMISTRY (cont.)								
108	Ionic, covalent, and metallic bonds	2.58	2.89	3.02	2.68	2.94	2.64	2.69
109	Electron dot formulas and structural formulas	2.20	2.44	2.75	2.54	2.48	2.49	2.41
110	Types of bonding related to electronegativity differences	1.76	2.00	2.36	2.06	2.08	1.89	2.01
111	Valence shell electron pair repulsion model (VSEPR)	1.53	1.78	2.19	1.95	1.87	1.60	1.93
112	Chemical and physical properties of compounds related to type of bonding and geometry	1.89	1.93	2.34	2.10	2.08	1.96	2.06
The Kinetic Theory and States of Matter								
113	Special properties of water (e.g., density of solid versus liquid)	2.82	2.71	2.87	2.73	2.82	2.62	2.77
114	Relationships among phases of matter, forces between particles and particle energy	2.47	2.51	2.89	2.73	2.54	2.62	2.57
115	Assumptions of the kinetic molecular theory	2.44	2.36	2.58	2.39	2.51	2.24	2.51
116	Relationships among volume/pressure/temperature/quantity for ideal gases	2.38	2.51	2.90	2.51	2.69	2.42	2.62
117	Real versus ideal gases	1.73	1.80	2.27	1.82	2.06	1.59	2.00
118	Phase changes for a pure substance	2.09	2.33	2.62	2.30	2.41	2.18	2.34
119	Relationships among evaporation rate/boiling temperature/vapor pressure	2.33	2.31	2.70	2.44	2.44	2.24	2.47
120	Characteristics of crystals	2.27	2.04	2.45	2.37	2.19	2.24	2.23
Chemical Reactions								
121	Equation balancing from written description of chemical reaction	2.49	2.78	3.02	2.77	2.79	2.60	2.81
122	General types of chemical reactions	2.44	2.82	3.06	2.78	2.76	2.49	2.84
123	Amounts of reactants and/or products using a balanced chemical equation	2.16	2.62	2.77	2.52	2.53	2.33	2.57
124	Endothermic and exothermic reactions	2.20	2.58	2.70	2.54	2.47	2.33	2.44
125	Collision theory and reaction rates	1.58	1.93	2.25	2.00	1.99	1.76	2.00

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D. CHEMISTRY (cont.)								
126	Activation energy and the effects of a catalyst	1.82	2.13	2.53	2.30	2.10	2.04	2.10
127	Rate-influencing factors in chemical reactions	2.33	2.45	2.62	2.41	2.49	2.24	2.40
128	Chemical equilibrium	2.18	2.34	2.47	2.28	2.48	2.07	2.37
129	Le Châtelier's principle	1.49	1.78	2.15	1.81	1.92	1.50	1.83
130	Factors that disturb equilibrium (e.g., temperature, pressure, concentration)	2.11	2.13	2.45	2.29	2.23	1.96	2.18
131	Oxidation and reduction reactions	2.00	2.32	2.64	2.24	2.47	1.98	2.48
132	Electrochemical cells and electrode reactions	2.00	1.96	2.40	2.09	2.20	1.80	2.16
133	Practical applications of electrochemistry	2.16	2.15	2.55	2.26	2.37	2.00	2.25
Solutions and Solubility								
134	Types of solutions	2.62	2.66	3.06	2.91	2.73	2.76	2.91
135	Selective nature of solvents (e.g., like dissolves like)	2.47	2.43	2.89	2.64	2.58	2.30	2.63
136	Effects of temperature and pressure on solubility	2.64	2.49	2.87	2.79	2.57	2.54	2.74
137	Dissolving process and the factors that effect the rate of dissolving	2.44	2.40	2.89	2.66	2.48	2.46	2.62
138	Concentration of solutions	2.71	2.70	3.13	2.94	2.77	2.80	2.94
139	Conductivity of solutions and the ionization process	2.24	2.06	2.72	2.53	2.28	2.17	2.50
140	Colligative properties of solutions	1.75	1.76	2.34	2.05	1.94	1.71	2.09
141	Acids, bases, and salts	3.16	3.19	3.44	3.28	3.20	3.17	3.25
142	pH	3.18	3.02	3.30	3.20	3.09	3.11	3.16
143	Strong versus weak acids and bases	2.73	2.72	3.07	2.96	2.74	2.87	2.81

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		N=46	N=48	N=55	N=81	N=95	N=46	N=69
D. CHEMISTRY (cont.)								
144	Buffer solutions	2.27	2.38	2.80	2.59	2.43	2.37	2.51
145	Overall Importance of Chemistry	2.89	2.91	3.15	3.03	2.94	2.82	3.02
E. BIOLOGY								
The Cell								
147	Prokaryotic and eukaryotic cells	2.39	2.51	2.69	2.61	2.49	2.52	2.37
148	Structure and functions of cellular organelles	2.64	2.87	3.18	3.05	2.76	2.84	2.82
149	Plant and animal cells	3.32	3.33	3.59	3.55	3.24	3.40	3.43
150	Structure and function of membranes (e.g., osmosis, active transport, plasmolysis)	2.91	3.04	3.06	3.06	2.99	2.93	2.99
151	Chemical reactions in respiration	2.67	2.54	3.02	2.79	2.68	2.53	2.76
152	Chemical reactions in photosynthesis	2.86	2.76	3.14	2.97	2.84	2.76	2.93
153	Interrelationships of metabolic pathways	2.09	2.11	2.67	2.41	2.24	2.02	2.27
154	Principles of enzymatic activity	2.26	2.17	2.43	2.31	2.32	1.95	2.27
155	Cell cycle	2.81	2.50	2.92	2.90	2.67	2.57	2.66
156	Stages and purposes of mitosis and cytokinesis	2.84	2.80	3.06	2.99	2.78	2.79	2.78
157	Stages and purposes of meiosis	2.81	2.91	3.02	2.97	2.84	2.81	2.81
Genetics								
158	Structure and replication of DNA	2.81	2.85	2.94	2.90	2.88	2.73	2.82
159	Basic mechanisms of protein synthesis	2.47	2.35	2.65	2.54	2.48	2.21	2.46
160	Causes and results of mutations	2.56	2.41	2.86	2.71	2.62	2.40	2.66
161	Genetic engineering	2.28	2.43	2.78	2.54	2.58	2.36	2.54

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		GEOGRAPHIC REGIONS			SEX		TEACHING EXPERIENCE	
		NE	C	S	F	M	≤10	>10
		N=46	N=48	N=55	N=81	N=95	N=46	N=69
E. BIOLOGY (cont.)								
162	Mendel's Laws and monohybrid and dihybrid crosses	2.67	2.93	3.10	3.01	2.85	2.95	2.91
163	Non-Mendelian inheritance (e.g., multiple alleles, multiple genes)	2.31	2.50	2.78	2.62	2.51	2.45	2.52
164	Interaction between heredity and environment	2.81	2.93	3.12	3.10	2.88	2.86	3.00
165	Human genetic disorders	2.67	2.76	3.02	2.92	2.80	2.71	2.94
Evolution								
166	Historical developments relating to the origin of life	2.56	2.40	2.76	2.68	2.56	2.68	2.53
167	Evidence for and factors affecting evolution	2.64	2.58	2.67	2.66	2.76	2.54	2.60
168	Theories and patterns of evolution	2.53	2.60	2.71	2.56	2.79	2.49	2.71
169	Isolating mechanisms and speciation	2.23	2.09	2.43	2.22	2.45	2.15	2.31
Diversity of Life								
170	General characteristics of life	3.42	3.33	3.65	3.51	3.38	3.40	3.50
171	Classification schemes (Five Kingdoms and nomenclature)	3.09	2.89	3.47	3.31	3.03	3.31	3.16
172	Characteristics of viruses, monerans, protists, fungi, plants and animals	3.02	2.83	3.45	3.24	2.99	3.12	3.16
Plants								
173	Nonvascular and vascular plants	3.02	2.93	3.06	3.14	2.81	2.98	2.96
174	Structure and functions of roots, stems, and leaves	3.14	3.20	3.37	3.24	3.20	3.14	3.25
175	Transport systems, nutrient uptake	2.91	2.83	3.04	2.94	2.92	2.71	2.94
176	Control mechanisms (e.g., hormones, photoperiods, tropisms)	2.30	2.20	2.78	2.49	2.40	2.05	2.47
177	Asexual reproduction	2.88	2.85	3.22	3.13	2.84	2.95	2.96
178	Sexual reproduction (flowers, fruits, seeds, dispersal, germination)	3.14	3.09	3.41	3.27	3.10	3.19	3.21

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E. BIOLOGY (cont.)								
Animals								
179	Digestion and nutrition	3.26	3.09	3.59	3.40	3.19	3.31	3.29
180	Circulation	3.26	3.11	3.55	3.36	3.20	3.29	3.29
181	Respiration	3.26	3.09	3.53	3.35	3.20	3.26	3.29
182	Excretion	3.19	3.04	3.53	3.31	3.15	3.17	3.25
183	Nervous system	3.21	3.04	3.51	3.28	3.17	3.17	3.26
184	Musculoskeletal system	3.02	2.89	3.35	3.09	3.05	2.98	3.19
185	Immune and lymphatic systems	2.84	2.78	3.22	2.95	2.94	2.73	3.04
186	Endocrine system	2.80	2.80	3.24	2.92	2.95	2.64	3.09
187	Reproduction and development	3.27	3.17	3.55	3.35	3.34	3.36	3.43
188	Homeostasis	2.89	2.74	3.22	2.96	2.94	2.69	3.01
189	Responses to stimuli (taxes, instincts, conditioned reflexes, learned behaviors)	2.79	2.61	3.15	2.92	2.79	2.70	2.96
Ecology								
190	Population dynamics (intraspecific interaction)	2.50	2.59	3.04	2.68	2.75	2.51	2.72
191	Life-history patterns (e.g., r and k strategists)	2.05	2.09	2.57	2.16	2.29	1.80	2.44
192	Interspecific relationships	2.77	2.72	3.12	2.91	2.78	2.69	3.00
193	Community structure and niche	2.75	2.85	3.02	2.86	2.91	2.78	2.97
194	Social behavior (e.g., dominance, hierarchy, altruism)	2.48	2.59	2.88	2.72	2.63	2.47	2.85
195	Species diversity in communities	2.73	2.52	2.90	2.73	2.74	2.64	2.78
196	Succession	2.75	2.61	2.88	2.77	2.70	2.60	2.82

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E. BIOLOGY (cont.)								
197	Aquatic and terrestrial ecosystems	2.98	2.65	3.04	2.95	2.87	2.82	3.01
198	Food webs and energy flow through ecosystems	3.20	3.18	3.20	3.18	3.23	3.27	3.21
199	Cycling of materials (e.g., nitrogen, water, carbon)	3.05	3.04	3.29	3.24	3.01	2.93	3.24
200	Biomes	2.91	2.59	3.04	2.90	2.87	2.91	3.03
201	Overall importance of Biology	3.33	3.34	3.70	3.49	3.41	3.45	3.48
F. EARTH AND SPACE SCIENCE								
Physical Geology								
203	Physical and chemical properties of minerals	3.05	2.74	2.96	3.05	2.85	3.02	2.89
204	General types of minerals (e.g., silicates, carbonates)	2.77	2.44	2.79	2.75	2.59	2.52	2.71
205	Types of rocks and the processes that form them	3.21	2.84	3.13	3.08	3.13	3.15	3.06
206	Folding and faulting	2.98	2.67	3.02	2.96	2.90	2.93	2.94
207	Earthquakes	3.19	2.88	3.15	3.14	3.03	3.13	3.08
208	Volcanoes	3.14	2.84	3.13	3.11	2.99	3.09	3.08
209	Rock magnetism	2.19	2.14	2.57	2.41	2.22	2.09	2.37
210	Isostasy	1.88	1.81	2.25	1.95	2.11	1.76	2.16
211	Evidence from seismic studies	2.42	2.14	2.53	2.38	2.44	2.20	2.46
212	Crust, mantle, and core	3.09	3.00	3.15	3.15	3.01	3.20	3.11
213	Lithosphere and asthenosphere	2.53	2.44	2.68	2.53	2.63	2.43	2.67
214	Convection in the mantle	2.51	2.33	2.70	2.67	2.53	2.61	2.65
215	Heat sources within the Earth	2.74	2.47	2.77	2.73	2.67	2.78	2.74

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		GEOGRAPHIC REGIONS			SEX		TEACHING EXPERIENCE	
		NE N=46	C N=48	S N=55	F N=81	M N=95	≤10 N=46	>10 N=69
F. EARTH AND SPACE SCIENCE (cont.)								
216	Hot spots	2.57	2.28	2.58	2.60	2.47	2.71	2.48
217	Plate tectonic theory	3.16	2.95	3.28	3.15	3.19	3.39	3.09
218	Physical and chemical weathering	3.12	3.05	3.23	3.18	3.09	3.28	3.03
219	Mass wasting (e.g., creep, slump)	2.33	2.10	2.45	2.34	2.35	2.41	2.25
220	Hydrologic cycle	2.93	3.00	3.10	2.99	2.99	3.00	2.95
221	Artesian and nonartesian wells	2.23	2.00	2.49	2.30	2.32	2.09	2.34
222	Process and structures of erosional/depositional features shaped by running water, etc.	2.95	3.00	3.15	3.04	3.04	3.00	2.91
Historical Geology								
223	Principle of uniformitarianism	2.14	2.07	2.56	2.27	2.35	2.25	2.29
224	Relative and absolute time (including dating techniques)	2.33	2.23	2.79	2.52	2.51	2.43	2.46
225	Geologic time scale	2.65	2.44	2.98	2.80	2.67	2.63	2.77
226	Principles of stratigraphy (e.g., cross relations, superposition)	2.02	1.93	2.42	2.09	2.29	2.07	2.20
227	Formation of atmosphere and hydrosphere	2.40	2.40	2.79	2.43	2.69	2.24	2.68
228	Types of fossils and evidence provided by fossils	2.72	2.60	2.96	2.77	2.84	2.59	2.80
229	Mass extinctions	2.44	2.30	2.77	2.58	2.56	2.48	2.55
Oceanography								
230	Wind-generated waves (e.g., formation, motion)	2.74	2.16	2.77	2.60	2.59	2.41	2.59
231	Tides	3.00	2.60	2.94	2.94	2.79	2.85	2.83
232	Ocean currents (global and local; surface and deep)	2.84	2.35	2.94	2.81	2.66	2.67	2.66
233	Shore processes (e.g., formation of dunes, beach profiles, wave effects)	2.65	2.30	2.77	2.77	2.45	2.52	2.58

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F. EARTH AND SPACE SCIENCE (cont.)								
234	Geographic location of oceans and seas	3.12	2.60	3.13	3.08	2.85	2.98	2.91
235	Physical and chemical properties of the ocean	2.71	2.42	2.89	2.70	2.68	2.49	2.75
236	Topography of the ocean floor	2.67	2.26	2.75	2.73	2.46	2.74	2.68
237	Effects of plate tectonics on the geology, biology, and topography of the ocean floor	2.86	2.70	3.00	2.94	2.83	3.02	2.91
238	Nutrient cycles of the ocean	2.70	2.37	2.81	2.65	2.65	2.57	2.61
Meteorology								
239	Physical and chemical properties of atmospheric layers	2.67	2.43	2.78	2.75	2.55	2.59	2.66
240	Seasonal and latitudinal variation of solar radiation	2.60	2.50	2.70	2.63	2.65	2.57	2.60
241	Heat budget of the atmosphere and the natural greenhouse effect	3.12	2.82	3.19	3.05	3.03	2.89	3.01
242	Causes of winds	3.05	2.91	3.02	2.97	3.02	2.91	2.97
243	Global wind belts	2.67	2.47	2.76	2.71	2.60	2.52	2.67
244	Variations in circulation (e.g., sea and land breezes, monsoons, jet stream)	2.79	2.56	2.76	2.75	2.66	2.50	2.79
245	Relative and absolute humidity (e.g., dew, frost point)	2.93	2.76	2.91	2.92	2.80	2.68	2.94
246	Cloud types and formation	2.91	2.80	2.94	3.00	2.78	2.89	2.97
247	Precipitation types and formation	3.00	2.87	3.07	3.08	2.88	3.02	3.04
248	Air masses (e.g., temperature, moisture content, source areas)	2.81	2.82	2.85	2.88	2.80	2.91	2.91
249	High and low pressure systems (including storms)	3.02	3.02	2.94	2.99	3.05	3.00	3.09
250	Frontal systems (e.g., cold, warm, stationary, occluded) and associated weather	2.95	2.98	2.98	2.99	2.97	3.00	2.99
251	Weather maps and station models	2.93	2.87	2.78	2.88	2.82	2.91	2.84
252	Weather forecasting	2.88	2.69	2.81	2.81	2.80	2.80	2.79

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F.	**EARTH AND SPACE SCIENCE (cont.)**							
253	Regional and local natural factors affecting climate (e.g., topography, rainfall, latitude)	2.72	2.82	2.83	2.90	2.74	2.86	2.84
254	Desertification, enhanced greenhouse effect, volcanic ash effects on climate	2.67	2.78	3.06	2.95	2.76	2.75	2.84
Astronomy								
255	Theories of and evidence for the origin of the universe	2.86	2.61	3.02	2.91	2.88	2.86	2.94
256	Structure of the universe (e.g., galaxies, novas, black holes, quasars, stars)	3.00	2.61	3.06	3.00	2.85	2.93	2.96
257	Large units of distance (e.g., astronomical unit, light-year, parsec)	2.81	2.36	2.85	2.67	2.75	2.52	2.82
258	Origin and life cycle of stars	2.74	2.32	2.78	2.72	2.59	2.57	2.74
259	Origin of the solar system	2.98	2.68	2.85	2.86	2.88	2.79	2.91
260	Major features of the Sun (including its energy source)	3.05	2.98	3.09	3.05	2.99	3.02	3.01
261	Structure of the solar system (e.g., planets, moons, asteroids, comets)	3.28	3.04	3.30	3.24	3.16	3.34	3.13
262	Phases of the Moon	3.05	2.89	3.19	3.03	2.99	3.00	3.01
263	Lunar and solar eclipses	3.09	2.91	3.15	3.08	3.01	3.07	3.09
264	Causes of seasons	3.33	3.24	3.31	3.24	3.34	3.34	3.25
265	Factors determining the length of a planetary year and day	2.81	2.56	3.02	2.88	2.75	2.91	2.72
266	Time zones on the Earth	2.70	2.62	3.02	2.73	2.81	2.52	2.85
267	Space exploration	3.09	2.62	3.15	2.97	3.05	2.95	3.13
268	Exploration of Earth from space	2.79	2.67	2.96	2.79	2.88	2.79	2.90
269	Overall importance of Earth and Space Sciences	3.33	3.12	3.23	3.23	3.23	3.23	3.31

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		NE	C	S	F	M	≤10	>10
		N=46	N=48	N=55	N=81	N=95	N=46	N=69
G.	**SCIENCE, TECHNOLOGY, AND SOCIETY**							
271	Issues associated with energy production and use	3.33	3.15	3.38	3.31	3.25	3.18	3.33
272	Issues associated with production and use of consumer products	3.07	2.80	3.22	3.15	2.91	3.05	2.94
273	Problems caused by the biological magnification of toxic materials in food chains	3.13	3.24	3.36	3.29	3.19	3.27	3.26
274	Conservation of nonrenewable resources (e.g., soil, water, metals, and fossil fuels)	3.49	3.41	3.48	3.45	3.44	3.48	3.52
275	Rel. of geographic distribution of natural resources/population patterns/global politics	2.86	2.85	3.12	3.07	2.87	2.95	2.95
276	Issues associated with biotechnology	2.67	2.89	3.04	3.00	2.82	2.84	2.92
277	Biological and chemical control of agricultural pests	2.62	2.80	3.00	2.92	2.78	2.82	2.88
278	Effect of agricultural practice on the environment	2.82	3.00	2.98	2.99	2.93	2.91	2.95
279	Use of science and technology to predict and prepare for natural disasters	2.82	2.85	2.90	2.93	2.81	2.86	3.00
280	Use of technology in everyday devices	3.04	2.98	3.18	3.16	3.02	3.14	3.11
281	Issues associated with health and wellness	3.09	3.04	3.32	3.28	3.08	3.18	3.14
282	Issues associated with technology transfer	2.68	2.54	2.82	2.72	2.72	2.70	2.72
283	Overall importance of Science, Technology, and Society	3.13	3.13	3.44	3.37	3.14	3.23	3.20

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